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CONTENTS

Abstracts of Principal Articles

Developments in the Production of Wickman Multi-spindle Automatics.........P. 528

Production of the Wickman automatic on a substantial scale was begun in 1937, and brief reference is made here to subsequent extensions to manufacturing capacity and the range of these machines. Attention is also drawn to typical applications including a set-up on a 7¼-in. capacity, 6-spindle machine, arranged for automatic loading. The existing machine tool and plant facilities are then described, with examples of operations on major components. Next, the machining of a cast-iron spindle drum is described in some detail, to afford an indication of the methods whereby intricate parts are made to the necessarily high standards of accuracy. Special equipment employed for this purpose includes slave mandrels, piloted boring bars with stop rings, a specially-adapted cylindrical grinder, and an arrangement for grinding the locator pad faces. Finally, there is a section concerned with finish grinding and checking the faces and tenon grooves of end-working tool slides. (MACHINERY, 92—7/3/58.)

The Production of Welded Steel Structures for Use in Aircraft..........................P. 541

In this article is discussed the use of welded steel structures in aircraft in place of components which hitherto have been machined from forgings, or solid billets, of aluminium alloy. This design change has been brought about by the increasing demand for higher performance aircraft and missiles, and the ability of steel to withstand the higher temperatures and thrusts thus incurred. Some of the designs and methods employed by the Rohr Aircraft Corporation for the manufacture of welded structures are described, also the use of adjustably-mounted welding jigs and fixtures. In addition, details are given of some of the company's machining, heat-treatment, and inspection methods and equipment. (MACHINERY, 92—7/3/58.)

Broaching Internal Helical Gears......P. 549

Internal helical gears of the order of 6 in. pitch diameter and 14 D.P. are being successfully produced by broaching, in roughing and finishing stages, and close limits of accuracy can be maintained. For this purpose, precision broaches of correct design are essential. Modified involute profiles on one or both flanks of the gear teeth can readily be provided. At the rough-broaching operation, the required helix angle is obtained by means of a lead bar which controls the rotation of the broach. For finishing, a broach with helical teeth on the pilot portion is employed. The rough-broached gear is placed on the guide by hand and is retained by a spring detent. It is thus ensured that the teeth of the gear are accurately aligned with those of the finishing broach. (MACHINERY, 92—7/3/58.)

Industrial Technics Co-ordinate Drilling Machine with Automatic Positioning P. 554

Industrial Technics (Southampton), Ltd., have built a co-ordinate drilling machine with automatic positioning, which incorporates an E.M.I. numerical control system, and Farrand Inductosyn units. It is claimed that the compound work-table can be positioned to an accuracy of $\pm$ 0·0002 in. Friction has been reduced to an almost negligible value by the use of Thomson re-circulating ball bushes, which run on hardened circular guide-members. Thomson re-circulating ball nuts are employed in conjunction with hardened and ground screws for traversing the table and carriage. Both of these members are locked in position by solenoid-operated clamps. The drilling spindle moves vertically in Thomson ball bushes, and is returned by a spring. Kopp variators, of 1 and ½ h.p., respectively, are provided for driving and feeding the spindle. In future, machines may be supplied with alternative table positioning arrangements incorporating the Ekco machine control system, which makes use of a series of Wheatstone bridge circuits, and associated master potentiometers. (MACHINERY, 92—7/3/58.)

Whaley Profile Milling Machine for Wing Models...................................... P. 559

A special profile milling machine for machining model wings from a variety of materials has been installed by the Lockheed Aircraft Corporation, U.S.A. Built by the Whaley Engineering Corporation, this machine has a cutter head which can be traversed along a longitudinal beam, supported above a surface plate, that serves as the machine table. The beam can be tilted in the horizontal and vertical planes, and rotated about a longitudinal axis, so that the wing form can be generated by a series of spanwise cuts. Before each cut, the beam is set by means of templates and dial gauges, and trapezoidal or delta wing shapes can be produced. (MACHINERY, 92—7/3/58.)

Contributions to MACHINERY

If you know of a more efficient way of designing a tool, gauge, fixture, or mechanism, machining or forming a metal component, heat treating, plating or enamelling, handling parts or material, building up an assembly, utilizing supplies, or laying out or organizing a department or a factory, send it to the Editor. Short comments upon published articles and letters on subjects concerning the metal-working industries are particularly welcome. Payment will be made for exclusive contributions.

IN FORTHCOMING ISSUES

Production of parts for Lambretta motor scooters

Utilization of Titanium

As is now well known, titanium and its alloys possess certain properties, notably high strength-weight ratio and heat- and corrosion-resistance, which render them very valuable materials for a variety of purposes. During recent years, owing to the enterprise of the various producers, and under the stimulus of demand for military purposes, output of titanium has been rapidly expanded. At the same time, there have been substantial reductions in the price of the material in various forms. Even so, titanium is still necessarily expensive, and the fact that it is also somewhat difficult to form, manipulate and machine, tends to augment the cost of finished components. If demand continues to increase, further economies will doubtless be achieved in the production of the material in raw and semi-finished forms. It is probable, however, that the extent of demand in the future will be increasingly determined by the scale on which the metal can be effectively employed for commercial, as opposed to purely military applications, for example in civil aircraft, chemical plant, and electronic equipment.

In these fields, it will be necessary to scrutinize costs more closely, and in particular it will be desirable to ensure that the available material is used as economically as possible. Increasing attention is properly being paid to the effective utilization of all engineering materials, as is evidenced, for example, by the growing interest which is being shown in cold forming processes whereby the weight of stock required to produce a certain part can often be substantially reduced. When, as in the case of titanium, the material is initially expensive and is costly to machine, it is obvious that all possible steps should be taken to ensure that the minimum is converted into swarf.

Extrusion is one method of processing whereby a form which is a reasonably close approximation to that finally required can often be obtained with a minimum of material loss, and there is no doubt that the wider use of extruded sections will result in considerable economies, particularly where the shapes involved are somewhat intricate. During the course of a paper read recently before the American Society of Automotive Engineers, Mr. N. J. Feola described an investigation which was carried out to determine the advantages of producing ring components for jet propulsion by extrusion, forming, and welding, as an alternative to the use of forged ring blanks. Extrusions for this purpose were successfully produced both in titanium and a titanium alloy, although for the latter material die wear was severe owing to the high temperature and pressure required. In this connection, the author commented that the problem of rapid wear would doubtless be overcome with the development of better die materials and lubricants. No mention was made of molten glass as a lubricant, although it is understood that, as in the case of steel, it has proved very successful for the extrusion of titanium.

For the investigation with which the paper was concerned, a thickness of 0·050 in. was added to all surfaces of the finished ring to provide an extrusion tolerance and to allow for machining to the finished dimensions. Even with this allowance, the material savings, as compared with the previous method, were substantial. An interesting aspect of the tests carried out was that extrusions were made directly from cast ingots, and, provided the reduction ratio was sufficient, were found to have physical properties comparable with those of sections extruded from forged billets. By utilizing cast ingots, both the cost of a forging operation and the loss of material involved are avoided, so that an additional substantial saving is achieved.

Rings were made from the extruded sections by radial draw forming, both the dies and the material being heated for this stage, and the ends were finally joined by flash-butt welding. With suitable control of conditions, satisfactory welds were obtained even when there were marked differences in the thickness of various portions of the ring section. Welded rings were expanded, hot, for sizing purposes, and at the finish-machining stage there were further economies by reason of the smaller amounts of metal to be removed.

Even without taking into account the savings obtained in the machine shop, it is stated that the cost per pound of a typical ring was reduced from 72 dollars when it was made from a conventional forging, to 43 dollars when the extrusion method was adopted. In addition, there was a considerable reduction in the overall time required to obtain finished rings.

It will be evident, from the results here reported, that with further developments in hot forming methods, substantial improvements in the utilization of raw titanium and its alloys should be achieved, with a consequent widening in the field of application.

K2

Developments in the Production of Wickman Multi-spindle Automatics

During the past ten years, some noteworthy results have been achieved by the more progressive British machine tool builders in meeting the demands of industry, both at home and abroad, for metal-working production equipment of advanced design, capable of the high performance necessary to permit economical manufacture of products for sale in markets that are becoming increasingly competitive. Among such firms, Wickman, Ltd., Tile Hill, Coventry, are prominent by reason of their progressive policy and achievements in the design and production of multi-spindle automatics, in which field they are well established, and now occupy a leading position.

Development of the Wickman automatic, with its well-known auto-setting mechanism which obviates the need for special cams, began in the early 'thirties, the first machine being delivered in 1937. Production on a substantial scale started in 1939, when the company built a new and up-to-date factory with a floor area of some 98,000 sq. ft. (subsequently extended to more than 200,000 sq. ft.), on a 100-acre site at Tile Hill, Coventry. During the war, the company completed more than 300 5-spindle automatics, as well as a wide variety of other machine tools, including large aircraft spar milling machines. In addition, some 300 Wickman automatics were built by outside contractors, under the direct supervision of Wickman engineers.

Extensions carried out progressively since 1946 have doubled the available factory and office space, and the activities of the machine tool division have been concentrated on the design and production of multi-spindle automatics, also the Wickman optical profile grinder, and, to a smaller extent, sliding headstock automatics. Some 1,400 people are at present engaged in the production of machine tools, and as an indication of the company's success in increasing productivity by the introduction of improved techniques and equipment, it may be noted that the annual output is now about five times that of 1947, whereas the floor space and number of employees have only been doubled. During the past ten years, export orders have accounted for nearly half of the machines that have been built.

It will be recalled that in 1952 the company suffered the misfortune of a major fire which destroyed the entire upper storey of the main block, and resulted in the loss of many valuable records. In spite of this set-back, a high level of production was maintained under difficult conditions, with many departments dispersed. Subsequently, a completely new and separate office block of some 35,000 sq. ft. was built.

Eleven different sizes of multi-spindle bar and chucking automatics are now being made, to cover a wide range of applications. The bar

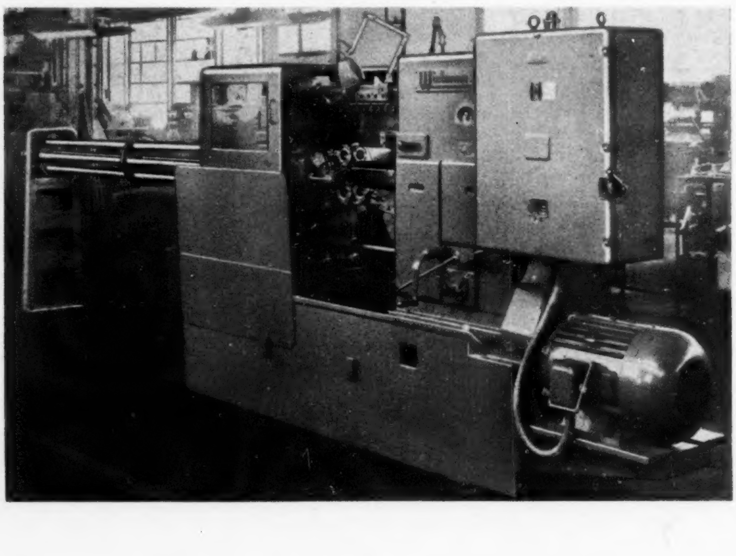


Fig. 1. The Wickman 1-in. Capacity, 6-spindle Bar Automatic which has Spindle Speeds up to 3,030 r.p.m.

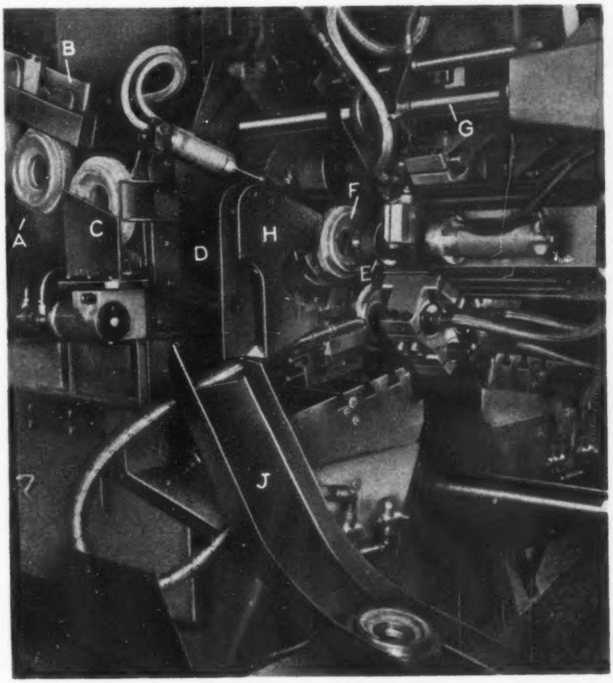


Fig. 2. Close-up View of a Wickman 7¼-in. Capacity, 6-spindle Chucking Automatic Fitted with Automatic Loading and Unloading Equipment

automatics include a 4-spindle, 3½-in.; 5-spindle, 1⅝-in. and 2¼-in.; 6-spindle, 1-in., 2¼-in., and 2⅝-in.; and an 8-spindle, 1⅝-in. machine. Chucking automatics consist of a 9-in., 4-spindle; a 6-in., 5-spindle; and 5⅝-in., 6⅝-in. and 7¼-in., 6-spindle machines.

Shown in Fig. 1 is the 1-in. capacity, 6-spindle bar machine, which was introduced in 1955, following development work on a prototype built in 1953. A machine of this type, it may be noted, was demonstrated by the company at the 1957 European Machine Tool Exhibition, held at Hanover. It was set up to produce a sparking plug body from free-cutting hexagon mild steel bar in a cycle time of only 3·5 sec., and the operations included threading, also picking up and back chamfering. This high rate of production was made possible largely by the application of Wimet tungsten carbide tooling, which enabled a spindle speed of 2,000 r.p.m. to be employed, thereby providing a cutting speed of 189 ft. per min. Features of the set-up included the use of two solid tungsten-carbide drills, independently driven at speeds of 509 and 486 ft. per min., and tungsten-carbide form tools with unusual lengths of form. The thread behind the shoulder of the component was produced with a 2-roll thread rolling attachment. A special attachment was provided whereby the piece was picked up from station six, after it had been parted-off, and the rear end of the bore was countersunk, thus eliminating a subsequent operation. For fairly simple components, the machine can be arranged with double bar feed, so that two parts are made at each cycle.

The versatility of both bar and chucking machines is considerably extended by the wide variety of special attachments now available, and provision is being made increasingly for the production of parts complete, which hitherto required secondary operations, for example flat milling, cross-drilling, and threading behind shoulders. As an example, the machining of 3⅝-in. long brass spindles for water taps, in a cycle time of 4½ sec. on a 1-in. capacity, 6-spindle automatic, may be noted. The operations on this part include threading the end, generating a tapering square-section, and cutting a trapezoidal thread on the body. One automatic will produce 3,800 spindles in an 8-hour day, whereas with a conventional capstan lathe, four days would be required to make this quantity, with an additional 2½ days' work on another machine, for milling the square ends.

An important section of the design office is devoted to the development of special tooling equipment and layouts to meet customers' requirements, and the company fully appreciates the advantages to be gained from the application of automatic loading and unloading units on chucking machines. An example is afforded by the set-up shown in Fig. 2, on a 7¼-in. capacity, 6-spindle machine, for boring, turning and facing 6-in. diameter cast-iron bearing housings in a cycle time of 25 sec., tungsten carbide tools being employed throughout. Castings are loaded into an inclined chute at *A*, which extends along the side of the machine and holds about 10 pieces. This chute can be connected directly to an overhead conveyor to provide for continuous automatic loading. Parts are released, in turn, by a latch mechanism *B*, into a holder *C*, which then swivels to allow the cast-

ing to fall into a secondary chute *D* at right-angles, where it is held ready to be picked up, by the bore, on a loading adapter *E*, for insertion in the 3-jaw chuck as at *F*. This adapter is carried on an arm attached to the shaft *G*, and is arranged to swing, also to move axially. The finished piece, which is released from the chuck just before reloading takes place, is directed by the guide channel *H*, into the chute *J*. Compressed air cylinders are employed for operating the loading adapter gripping fingers, also the release latch and swivelling mechanism for the magazine chutes.

Automatic loading and unloading equipment has also been applied to a 6⅝-in. capacity, 6-spindle chucking automatic employed for machining a cast iron clutch pulley in a cycle time of 28 sec. A feature of this set-up is that the machine is arranged for double indexing, and work is automatically removed at station 5, reversed, and reloaded at station 6, so that operations can be carried out on the opposite face. With this arrangement, the need for a separate operation to complete the piece has been avoided. At this set-up, again, tungsten carbide tools are extensively employed.

By reason of the auto-setting mechanism, which enables a set-up to be quickly changed, Wickman automatics are particularly suitable for handling relatively small batches of parts as well as for long production runs. Further economies can often be effected, in connection with batch production, by arranging the shop order sequence for different components in such a manner that the change-over is made, as far as possible, for a part of generally similar type, so that a minimum of tool changing is involved. This procedure, it is understood, has been adopted with considerable success by several companies in the motor industry and is greatly assisted by the facilities for changing the lengths of travel of the tool slides, without the need for changing cams.

DEVELOPMENT OF PRODUCTION FACILITIES

The steady expansion that has taken place since 1946 has resulted in the progressive installation of the most up-to-date machine tool equipment, and under the company's carefully planned policy of plant replacement, a stage has now been reached where the greater part of the production equipment is less than 10 years old.

As is usual in the machine tool industry, production is necessarily carried out on a batch basis, and sets of components are issued from the stores to the assembly lines, for building machines to meet customers' specific orders. In this connection, a revised system of progress control is now being introduced which will afford important advantages as a result of improved co-ordination of the work flow with the sales programme, and consequent reduction of the component stocks which it is necessary to hold. The procedures that have been developed are based on the Adrema system whereby material requisitions, inspection, progress and payment tickets, and all other paper-work records required, can be rapidly prepared by printing from stamped metal plates. Control of the issue of component orders will be based on maximum and minimum stocks, careful account being taken of the time cycle for making the particular part, and a forward loading system will be established for the machine shop to ensure efficient plant utilization as well as the maintenance of the delivery dates which have been scheduled. At

Fig. 3. A View of the Assembly Lines for Multi-spindle Automatics at the Tile Hill Works of Wickman, Ltd.

Fig. 4 A Large Heller Plano-milling Machine Set Up for Operations on Three Main Drive Housings for 1-in. Capacity, 6-spindle Automatics

present, the time cycle from raw material to finished machine is about 7 months, and from the issue of component parts to completion of the machine, 10 weeks.

In conjunction with the introduction of the new progress control system, the tool stores is being completely reorganized to provide facilities whereby all the tools required for a particular job will be brought to the operator at his machine. The object is to ensure that the work and tools, together with the relevant part drawing and operation layout, are available immediately the previous job has been completed, so that the operator can proceed at once with the new job, after recording his starting time on the clock. Component drawings for shop use, it may be noted, are mounted on stiff card, with the operation layouts pasted on the back. To enable Powers-Samas machines to be employed in connection with forward loading, the various types of machines have been designated on the layouts according to a code number system.

In general, the machine tools throughout the factory are grouped according to type, and in each section a control compound has been provided from which raw material, and components in process of machining, are issued according to predetermined schedules. Fork trucks and special pallets are being used effectively for the movement of work. The system ensures that any special tooling and attachments which are being made to meet customers' requirements, are available for try-out as soon as the basic machines are completed.

When component orders for a batch of automatics of a particular type are issued, the major castings comprising spindle drums, drum housings, drive housings, bridge members, and bases, are passed through the shops in numbered sets, and after the preliminary machining operations have been performed, the castings of a set are brought together and checked for alignment. The results of the tests are recorded and taken into account when the finish machining operations are being performed, so that a high degree of accuracy is ensured at the final assembly without the need for rectification by hand fitting. In a Wickman multi-spindle automatic, there are more than 800 components, all of which, with the exception of the frame castings already mentioned, are produced on a substantially interchangeable basis. This procedure, although necessitating extensive use of jigs and fixtures, and the exercise of great care in the machine shop, is essential to ensure a smooth flow on the assembly line. Of equal importance, is the fact that it provides for easy maintenance when the automatics are in service.

The extent of the main assembly line, as at present arranged, will be evident in Fig. 3. This section is continued in the foreground to form a final test bay, and, after acceptance, the machines are masked and moved on a trolley into a water-wash spray booth for finish painting. Machines that are equipped with special tooling or work handling equipment are fully tried out and demonstrated before delivery, and, if desired, instruction on operating techniques for Wickman automatics can be arranged for setters from customers' works.

MACHINE TOOL AND PLANT FACILITIES

The machine tools installed, which, as already mentioned, are all of up-to-date design, comprise, for the most part, standard, general-purpose types on which jigs, fixtures and special tools are exten-

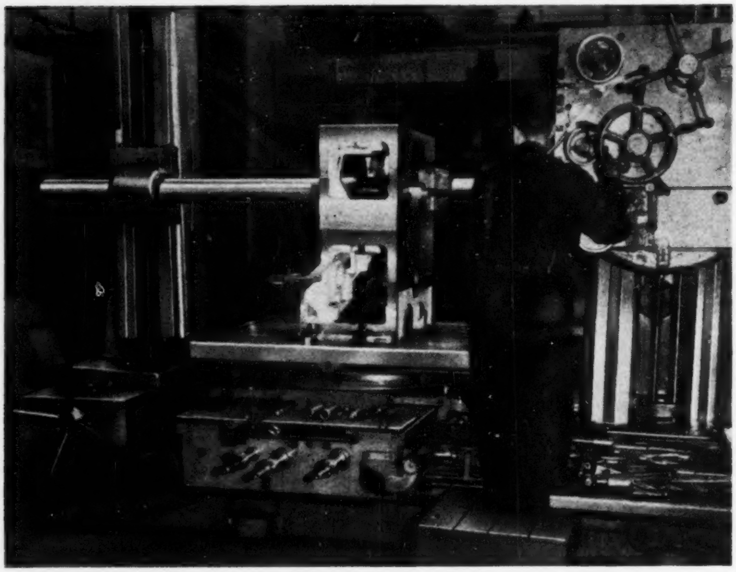


Fig. 5. Boring a Drum Housing for a 1-in. Capacity, 6-spindle Automatic on a Collet & Englehard BFf 115 Horizontal Borer

sively employed, to ensure economical production to the required high degree of accuracy. Horizontal borers find an important place, and in addition to Kearns, Richards, Giddings & Lewis and Gilly machines, for example, there are nine borers supplied by Collet & Engelhard, for whom the company are the sole selling agents in this country. Other German-built equipment in use, for which the company are the agents, includes a large Heller plano-milling machine, Naxos-Union cylindrical grinders, and a Kopp horizontal duplex slot and keyway milling machine. The fact that these machines are in operation in their own works, enables the company readily to carry out practical demonstrations for the benefit of prospective customers.

The Heller plano-milling machine is seen in Fig. 4, set-up for machining the side faces of three drive housings with an inserted-blade Wimet tungsten carbide cutter. This machine is equipped with three 25-h.p. spindle heads, and the traverse motions are obtained by screws driven by hydraulic motors which provide a wide range of steplessly-variable feed rates. Fig. 5 shows a Collet & Engelhard type BFf 115, 4½-in. spindle, horizontal borer in operation on a drum housing which is finished to 14·506/14·508 in. diameter. A Devlieg 4B Jigmil is available for precision co-ordinate boring operations, for example on prototype parts.

In addition, several Kendall & Gent plano-milling machines are installed, and for the batch production of components such as gear blanks, Herbert No. 3A, 4A, and 5A, auto-lathes are employed. Spindle forgings, which are usually supplied as thick-walled alloy steel tubes, upset to form the enlarged collet ends, are turned on a Skoda centre lathe, equipped with a special carriage incorporating two sets of multiple stop drums and associated latches, which are pivoted progressively into engagement by hand to control the diameter and length dimensions of the workpiece. Spindles for the smaller sizes of automatics are usually handled in batches of 50.

Equipment in the gear cutting section includes Lorenz shapers, and gear teeth and splines are finish ground on Orcut formed-wheel machines. Precision screws, pitch screws, worms, and retaining threads on spindles are ground on Matrix machines. Mention may also be made of three Schneider slideway grinders, which are employed, for example, for finishing the hardened ways of tool slides. Asquith radial drilling machines include some of the Tru-Speed type, with steplessly-variable spindle speeds, and a 8-ft. OD2 machine is equipped with a double-sided rotary table unit which is mounted in horizontal trunnion bearings over a pit, so that fixtures for two large castings can be accommodated. Planing machines in use include a recently-installed 6- by 6- by 14-ft. type, one of several by Planers, Ltd., for whom Wickman are the selling agents. This machine is shown in Fig. 6, set up for planing the seating faces of a base casting for a 1-in. capacity, 6-spindle automatic, with two tungsten carbide tools which take ½-in. deep cuts at a feed of 0·040 in. per stroke, and a cutting speed of 100 ft. per min.

As might be expected, the company's Wimet tungsten carbide cutting tools are used extensively throughout the works, and particular care is taken to ensure correct servicing.

Three American-built Rowbottom machines are

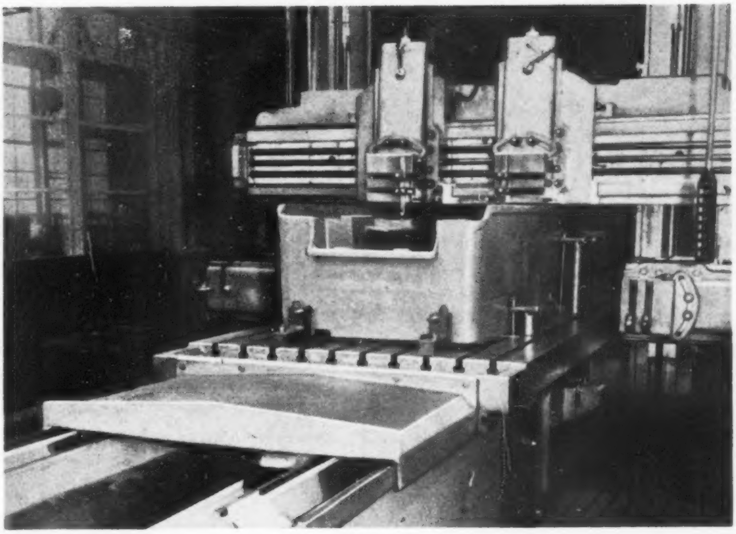


Fig. 6. Planing the Seating Faces of a Base Casting for an Automatic on a 6- by 14-ft. Planers Machine

employed for milling, and subsequently grinding, the profiles of the hardened steel cams incorporated in the auto-setting mechanism for the tool slide movements of Wickman automatics. On each Rowbottom machine, the required form is reproduced mechanically from a plate-type master which controls the vertical movement of the horizontal-spindle cutter head. The work-head can be swivelled through 90 deg., in trunnion bearings, to permit of cutting either plate-type or bell cams, and there is a low range of work speeds for milling, and a higher range for use when grinding the cam profile. Profile milling and grinding of toggle levers for the collet-operating mechanism is also carried out on these Rowbottom machines.

Drive housings, drum housings, bridge castings, bases, spindle drums, and all of the other castings are heat treated for stress relief before any machining operations are performed, and, in some cases, the castings are heat-treated again after certain preliminary machining operations have been completed. This heat treatment is carried out in a self-contained section which also houses a Tilghmans Wheelabrator unit, wherein the castings are thoroughly shot cleaned. In addition, there are facilities for hand fettling, and painting the castings with primer. There are two heat treatment ovens, which are arranged side by side at the end of the building and are provided with loading doors opening on to the works yard where the castings are stored in the open for weathering. Upon completion of the heat-treatment cycle, the castings are unloaded inside the building and transferred directly to the Wheelabrator.

TYPICAL PRECISION MACHINING TECHNIQUES

As examples of the precision machining methods which are employed by the company in the production of multi-spindle automatics, attention is drawn

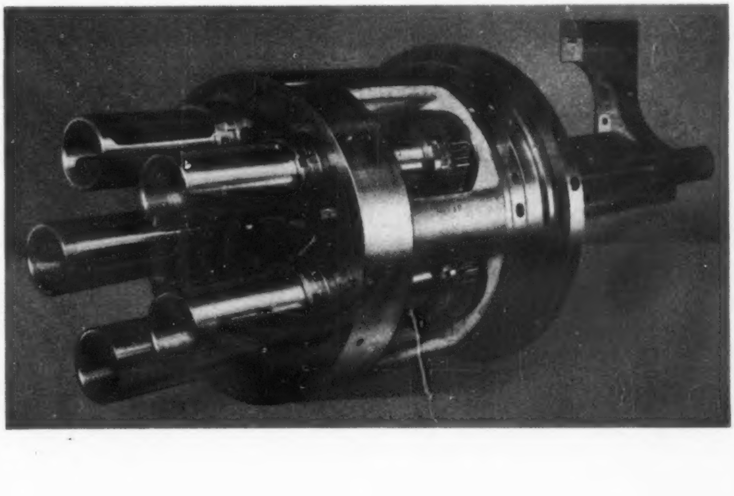


Fig. 7. Drum and Spindle Assembly for a Wickman 1¼-in. Capacity, 5-spindle Bar Automatic

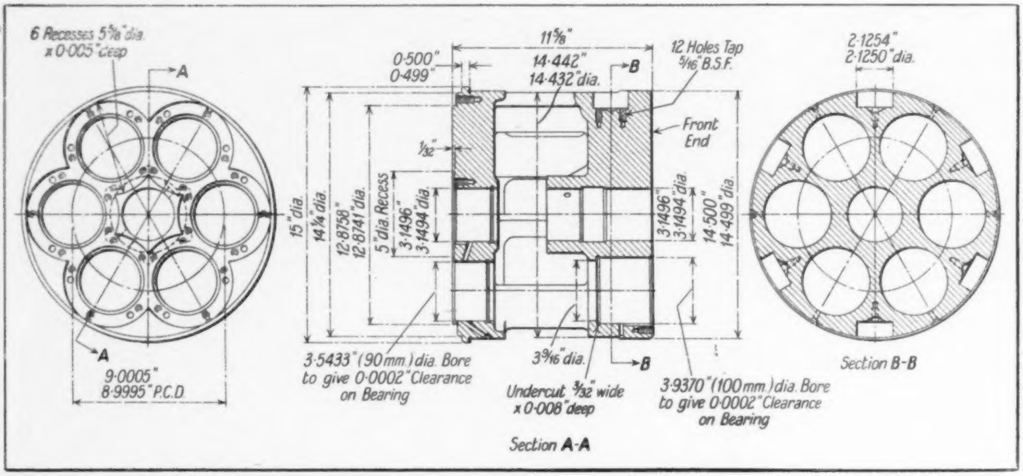


Fig. 8. Details of the Spindle Drum for a Wickman 1-in. Capacity, 6-spindle Automatic are Shown in these End and Sectional Views

to some of the operations involved in machining the cast-iron spindle drums. It will be appreciated that the accuracy of the spindle drum assembly largely determines the tolerances that can be maintained on the workpieces produced on a machine, and much thought has been given to solution of the problems involved in maintaining the necessary standard. A spindle drum assembly for a 1¾-in. capacity, 5-spindle automatic, with the centre guide tube and end-working tool slide fitted, is shown in Fig. 7, and some details of the drum for a 1-in. capacity, 6-spindle machine are given in the drawing, Fig. 8.

Operations start with stress relieving and shot blasting the casting, which is then checked and marked out, with the aid of a template, as a guide when performing the preliminary machining operations on a 48-in. vertical turning and boring mill. First, the casting is faced and turned to 14·750/14·757 in. diameter at one end, and it is then reversed for rough turning the stepped portion and facing to a length of 11⅝ in. Next, a check is made for hardness on the outside surface, and it is specified that the metal must be sound and the hardness between 190 and 230 Brinell. The spindle bores are now marked out, a template being again employed, and the six holes are rough machined on a horizontal borer equipped with an indexing fixture and piloted tool bars.

Before any further machining operations are performed, the casting is stress relieved and shot blasted, for a second time, and the inside surfaces are also hand fettled and coated with primer paint. At two operations on a 4-ft. vertical turning and boring mill, the casting is faced at each end to finished length and the diameter steps are turned and undercut—a grinding allowance being left on the close-tolerance dimensions. On a horizontal borer, the centre hole is rough- and finish-machined to a tolerance of 0·0002 in., and recessed 5 in. diameter by 1/32 in. deep, and the centre bore is then lapped at a bench operation, to instructions from the inspection department, to provide exactly the required fit for a selected, nitrided and ground centre tube.

The six radial recesses which accommodate the indexing location pads are rough-bored on an Asquith radial drilling machine, with the casting mounted in a jig, and, at the same set-up, the two holes in the bottom of each recess are drilled and partially tapped 5/16 in. B.S.F. Various drilling, reaming and tapping operations follow, and a hardened and ground arbor is then fitted in the centre bore, which serves for location purposes during the subsequent operation of finish-boring the six indexing pad holes, finish-machining the six spindle bores, grinding the stepped outside diameter, grinding the indexing location faces after the pads have been assembled, and checking the accuracy of the bore centres.

An arbor for one of the larger drums, as used on a 1¾-in. capacity 8-spindle automatic, is shown in Fig. 9. Flanges with clearance holes for fixing screws, and reamed holes to take location dowels, are provided at *A* and *B*, the spindle drum being fastened to the flange *A*, and the index plates for the various operations, to the flange *B*. For each

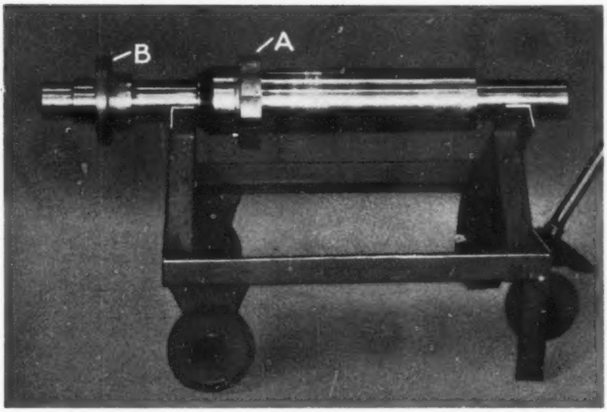


Fig. 9. The Finish Machining Operations on the Spindle Drum are Carried Out with the Workpiece Mounted on a Slave Mandrel of the Type Here Shown

type of spindle drum, a number of arbors is available which are of graded diameters, and an arbor, as nearly as possible 0·0002 in. less in diameter than the centre bore of the particular drum, is chosen. For storing the arbors, special vertical stands, or, for the heavier types, wheeled trolleys as shown in Fig. 9, are provided, to ensure that no damage can occur when they are not in use. The smaller sizes of drums, it may be noted, are handled in batches numbering up to 15, so that the arbors required represent an appreciable item of precision tooling equipment. After the arbor has been assembled, the spindle bores of the drum are stamped 1 to 6 for reference purposes, and the drum is also stamped with the arbor number, an individual identification number, and the part number. When fitting the arbor, the rear face adjacent to the drum bore is scraped so that it beds accurately against the arbor flange, and, before any finish machining operations are performed on the drum and arbor assembly, it is given a concentricity check by the inspection department.

Finish boring of the six locator pad holes is the first operation carried out with the drum mounted on the arbor, and the set-up on a Collet & Engelhard horizontal borer is shown in Fig. 10. This fixture is also employed when finish-machining the spindle bores, the bar being piloted in front and rear bushes, as at *A*. Hardened steel, capped bearings *B* support the arbor, and the index plate attached to the outer flange of the arbor is seen at *C*. The indexing arrangement is similar to that employed on a specially-designed locator pad grinding machine shown in Fig. 13, which will be described later.

Machining of the locator pad bores to a tolerance of 0·0004 in. on diameter is carried out at two stages, and, at the first stage, a 4-tooth, end-mill type, Wimet tipped cutter *D* is used to finish the bottom face, leaving approximately 0·010 in. on the diameter. Finished size is then obtained with a Wimet tipped cutter having six teeth. Each cutter is provided with an adjustable stop collar on the shank, and is guided by a slip bush in a bracket *E*, which is bolted to the fixture base.

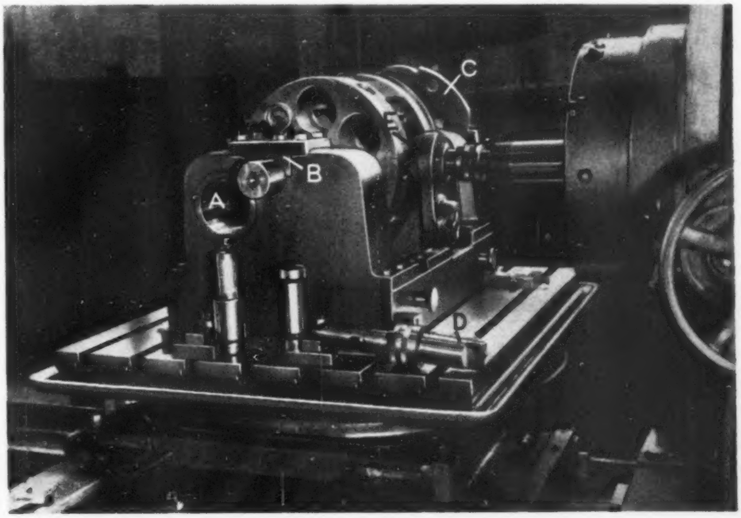


Fig. 10. Set Up on a Collet & Engelhard Horizontal Borer for Machining the Locator Pad Holes in a Spindle Drum. The Same Indexing Fixture is Used for Boring the Spindle Holes

Following this operation, the two holes in the bottom of each recess are finish-tapped $\frac{5}{16}$-in. B.S.F. by hand, to receive the fixing screws for the hardened-steel locator pads, and the latter are then assembled. A tight, expansion fit is obtained for the pads by cooling them in trichlorethylene to which has been added Drikold solid carbon dioxide. A pad is seen in position at *A* in Fig. 12, which is a view of the set-up employed, at a subsequent stage, for finish-grinding the stepped outside portion. For assembly, the pad is first attached to a holder by means of a screw which enters a tapped central hole provided for this purpose, and is located angularly with reference to sighting faces on the holder. The pad is then immersed for a short time in the trichlorethylene, and when it has cooled it is inserted in the drum recess, with the holder located on a peg fitted into one of the drilled holes in the drum end face. When the pad has expanded in the recess, the holder is removed, and the two fixing screws are inserted. The central tapped hole in the pad also serves to accommodate a jack screw should it be necessary to remove the pad for any reason.

The set of four piloted tool bars employed, in conjunction with the fixture seen in Fig. 10, for semi-finish and finish-boring and facing the spindle bores, after the six locator pads have been assembled, is shown in Fig. 11. All the bars are provided with adjustable, stop rings for controlling length dimensions, and a floating drive arrangement is employed, the torque being transmitted by means of a cross pin. The cutters in the bars are Wimet tipped. Semi-finish boring is performed with the bar at *A*, which is fitted with double-cutting tool-bits, each held by a central, taper-ended screw engaging a mating recess in the tool body.

The bar at *B* carries two out-feeding tools for producing the $\frac{3}{32}$-in. wide spring-clip grooves, the feed motion being imparted by a spring-loaded, sliding, central rod, which is provided with wedge faces that engage the ends of the tool shanks. This rod is coupled to the machine spindle and forms the driving member. A hardened-steel ball is provided at the outer end of the bar, which makes contact with an end stop face on a slip bush *C*, inserted in the rear guide bush of the fixture. With this arrangement, the recessing tools are brought to the required axial cutting position, and continued traverse of the machine spindle then causes them to feed outwards.

The $5\frac{5}{8}$-in. diameter by 0·005-in. deep recesses in the drum end face, which must be square with the spindle bores within 0·0005 in., are machined with the 4-blade cutter at *D*, and finish-boring is carried out with single-point tools in the bar *E*. For these single-point tools, a differential screw arrangement is provided for fine adjustment of the cutting size.

BORING TO SUIT GRADED ANTI-FRICTION BEARINGS

The high degree of running accuracy that is obtained for the spindles of Wickman automatics is a direct result of the extreme care that is taken in finishing the drum bores, grinding the spindles, and mounting the anti-friction bearings, and the procedures that have been established from extensive experience are worthy of attention.

Referring to the drawing, Fig. 8, it will be noted that nominal sizes—in this instance 90 mm. and 100 mm.—are given for the spindle bores in the drum, with the stipulation that the bores must be machined to give 0·0002 in. clearance for the bearing outer rings. High-precision anti-friction bearings specially made for machine tool applications are, of course, employed, and these bearings are supplied by the makers marked with the variations from nominal of the outside diameters and bores, measured to 0·0001 in. This information is also given on the boxes in which the bearings are packed. Although the variation

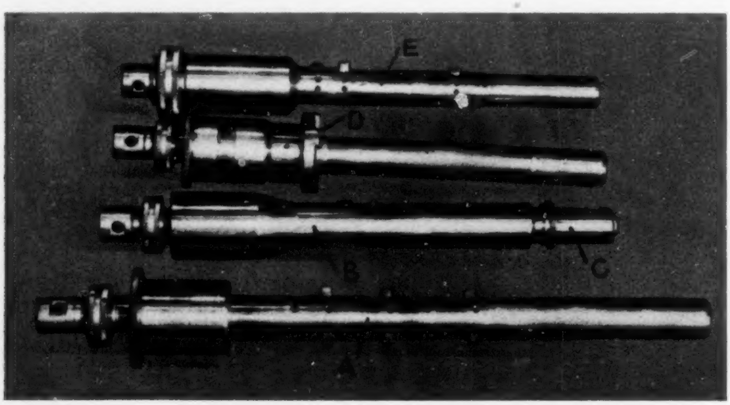


Fig. 11. The Set of Tool Bars Employed for Boring and Facing the Spindle Bores of the Drum

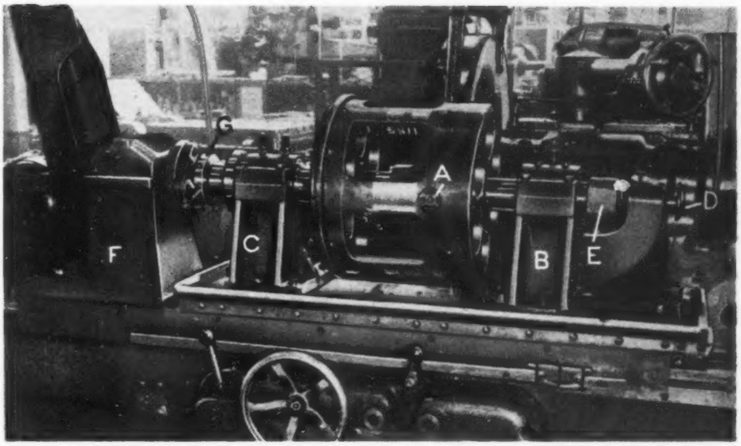


Fig. 12. A View of the Landis Cylindrical Grinder which has been Specially Adapted for Finish-grinding the Spigot Diameters and Faces of Spindle Drums

does not exceed 0·0003 in., the bearings are stored in batches graded to 0·0001 in. as nearly as possible, and records of the bearings available are maintained by the planning department.

When a shop order is issued for a batch of spindle drums and spindles, the bearings to be used are allocated from stock, with the bearings comprising each set as nearly as possible of the same grade size. As previously mentioned, the drums of the batch carry separate identification numbers, and a record sheet is prepared for each drum, on which are tabulated, for each spindle position, the outside diameters and bores of the front and rear bearings that are to be used.

Reference is made to this record sheet by the operator on the horizontal borer, when the spindle bores are being finish machined, the aim being to provide a clearance of 0·0002 in. for each bearing. To meet contingencies, provision is made, under instructions from the inspection department, for honing bores which may have been machined very slightly under-size, and for this purpose, a Delapena honing head, usually operated by hand, is employed. A bearing of another grade size is selected should any spindle bore inadvertently be machined oversize.

Upon completion of the finishing operation on the drum bores, the exact sizes are recorded by the inspection department and the spindles are then finish ground in sets to provide an interference fit of 0·0002 in. for the bearings selected for the particular drum. With the procedure described, the most satisfactory running performance is obtained for the spindles, and to ensure that this performance is maintained in service, the dimensions of all the spindle bearings fitted are recorded on the final inspection chart of the machine, so that replacement bearings of exactly the same size as those originally fitted can be provided, when required.

After the spindle bores have been finished, the stepped outside portion of the spindle drum is ground on a Landis hydraulic cylindrical machine specially modified for the purpose, as shown in Fig. 12. The wheel-head has been raised to give the required centre height for handling all sizes of spindle drums, from 16 to 23 in. diameter, and new work-head and tailstock units have been fitted to support and rotate the drum and arbor assembly.

To carry the arbor, capped, plain phosphor-bronze bearings are provided in the pedestals *B* and *C*, bolted to the machine table, and for location endwise, a shoulder on the arbor is held against the inner face of the left-hand pedestal by a screw at *D*, which bears against a thrust adapter *E*. The latter is assembled to the end of the arbor, and is fitted with a hardened steel ball which takes the thrust.

A worm reduction gear is incorporated in the driving head *F*, and three work speeds are provided by V-belts and stepped pulleys. Rotation is imparted to the workpiece through two radially-projecting pegs on an arbor adapter *G*, which are engaged by two coned bosses on the spindle flange of the driving head. These bosses are carried on pivoted arms which permit them to be adjusted into contact with the two pegs, and they are then clamped. Approximately 0·015 in. on diameter is removed at the finish grinding operation, and although there is a tolerance of 0·001 in. on the 14½-in. diameter, the diameter difference between the front and rear lands must not exceed 0·0003 in. The outside surface of the drum must be concentric with the centre bore within 0·0004-in. total indicator reading, and the flange faces are required to be square with the periphery within 0·0003 in.

GRINDING THE DRUM LOCATOR PAD FACES

For the important operation of grinding the faces of the locator pads, upon which the accuracy of spindle drum indexing depends, the company have designed units of the type shown in Fig. 13, for handling the various sizes of drums. The work and arbor assembly is supported in capped bearings, and a large-diameter index plate *A* is fastened by screws to the outer flange of the arbor. A withdrawable pin *B* engages the hardened and ground bushes of the index plate. In addition, in order to take up all clearance, an eccentric clamp at the rear is brought into contact with a hardened steel pad, as at *C*, by rotating a knob.

In the operation of the automatic, the spindle drum is indexed by gearing from a Geneva wheel, being rotated slightly past its final position and then smoothly drawn back, by a powerful toggle clamp, on to a hardened steel location latch, where it is positively locked in position. Consequently, there are two faces which require to be ground on each pad, namely, the latch face and the locking face, as indicated in Fig. 14. For this reason, front and rear grinding head slides *D* and *E*, are provided on the unit seen in Fig. 13.

The operation is carried out with a 1⅜-in. diameter wheel mounted on the spindle of an Ajax III air-driven grinding head in a cradle on a slide *F*.

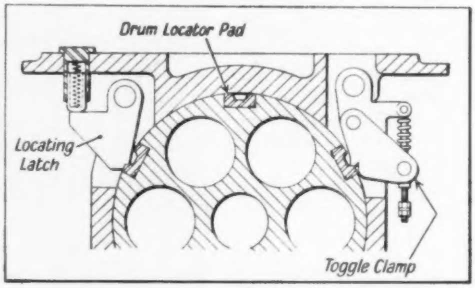


Fig. 14. Diagram Showing the Spindle Drum Locating and Clamping Mechanism on a Wickman Automatic

The latter is arranged for screw adjustment on the steeply inclined face of the angular slide *D*, for applying the cut, with reference to a large graduated dial, and the angular slide can be moved transversely by means of a hand lever, through a rack and pinion. End stops limit the forward and backward movements. A truing diamond, carried in a pivoted holder at *G* on the front of the slide base, is provide for dressing the lower face of the grinding wheel. Similar arrangements are provided for the head *E*.

First, all the pad faces—either locking or latch as the case may be—are cleaned up, using the index plate *B* for location purposes, and with the grinding wheel maintained in the one setting. The index plate provides for an indexing accuracy of about 0·0007 in., but on the latch faces of the pads a spacing accuracy within 0·0002 in. must be maintained, and on the locking faces, 0·0005 in. This degree of precision is obtained by selective grinding, according to readings shown on the dial indicator of a pitch gauge *H*, which rests on the ground periphery of the drum and is fitted with a radiused anvil at the rear. The dial gauge reads to 0·0001 in. and is also provided with a radiused anvil.

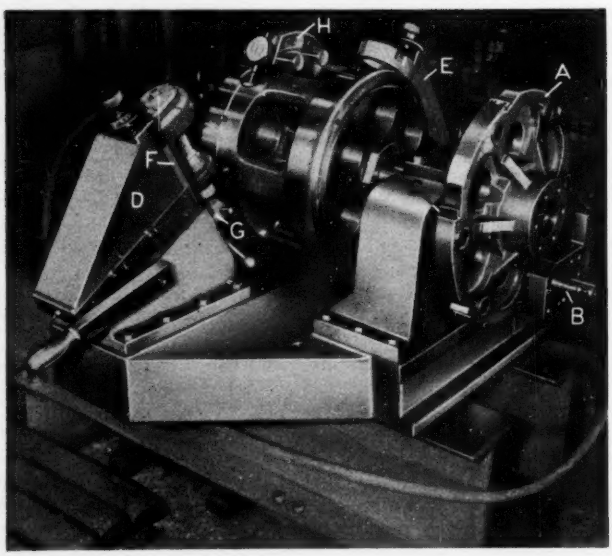


Fig. 13. Equipment Specially Developed by the Company for Finish Grinding Drum Locator Pads to Provide a Very High Degree of Indexing Accuracy

Upon completion of this pad grinding operation, the drum is inspected for accuracy of indexing, and spindle bore centres. In connection with the bores, the allowable difference in the pitch circle radii at the front end is only 0·0004 in., and the chordal dimensions must also be within 0·0004 in. At each position, the radial or tangential run-out of the

rear bore relative to the front bore must not exceed 0·0005 in. per ft.

The arbor on which the drum has been mounted throughout all the important machining operations is then removed, and after the remaining holes have been jig drilled, and tapped where necessary, and a series of oil grooves cut in the bores, the casting is finish painted in preparation for delivery to the assembly shop. Each spindle drum assembly, complete with the centre tube for the end-working slide, is run in and tested as a unit on a special rig before it is built into the drum housing of the machine. It may be noted that the run-out of the collet seatings in the spindles must not exceed 0·0005 in. total indicator reading.

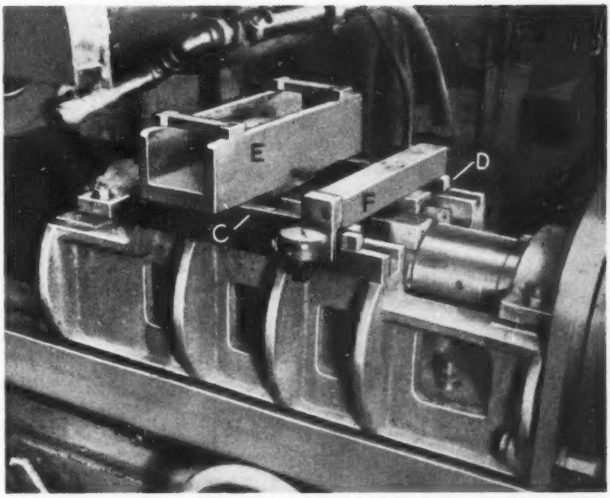


Fig. 16. Special Gauges are Employed for Checking the Tool Slide at the Finish Grinding Operation, while it is Still Mounted in the Fixture

GRINDING THE FACES AND TENON GROOVES OF END WORKING TOOL SLIDES

Another important operation, to which reference may be made, provides for finish grinding the tool faces and tenon location grooves of the heat-treated, alloy-steel end-working slides, and the equipment that is employed on a surface grinder is shown in Fig. 15. The tool slide shown is for a 1-in. capacity, 6-spindle automatic.

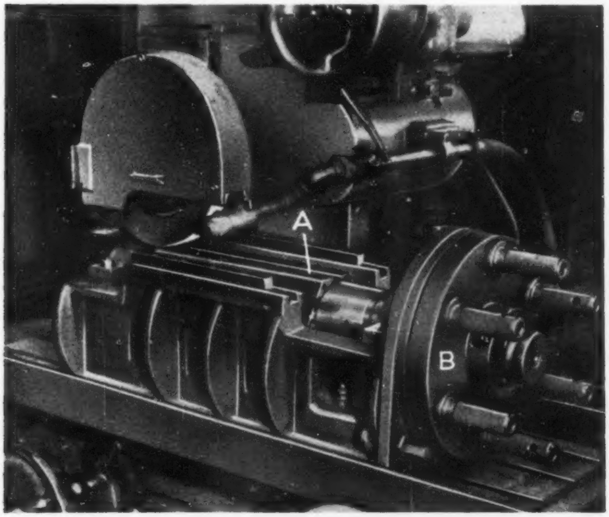


Fig. 15. Set-up on a Surface Grinder for Finishing the Faces and Tenon Grooves of the End Working Tool Slide of a 1-in. Capacity, 6-spindle Automatic

The workpiece *A* is located, by the finish-ground centre bore, on a mandrel which is supported in capped bearings in the fixture, and at its outer end the mandrel carries an index plate *B*, fitted with six location pins, so that dividing errors are reduced to a minimum. By changing the index plates, this fixture can also be used for handling tool slides for 1⅜-in. capacity, 5-spindle automatics.

Approximately 0·015 in. is removed from each face, and 0·012 in. from the side of each tenon groove. For the latter, a width tolerance of 0·0005 in. is specified, and the slot must be central to the bore within $\pm 0{\cdot}0003$ in. The tolerance on the dimension from the ground face to the bore centre-line is $\pm 0{\cdot}0005$ in.

To facilitate production, provision is made for checking the work while it is still mounted in the fixture. Special gauges, as seen in Fig. 16, are employed for this purpose, and incorporate dial indicators reading to 0·0001 in. These gauges are located on hardened and ground datum

blocks *C* and *D*, which are fastened to the fixture, and that indicated at *E* is employed for checking the height of the ground face from the centre line of the workpiece. The gauge *F*, fitted with a dial indicator which engages the side face of the datum block, serves for checking that the tenon groove is central with the bore, within the prescribed tolerance, and it can be reversed and applied to the opposite face of the groove. A " go " and " not go " slip gauge is used to check the groove width.

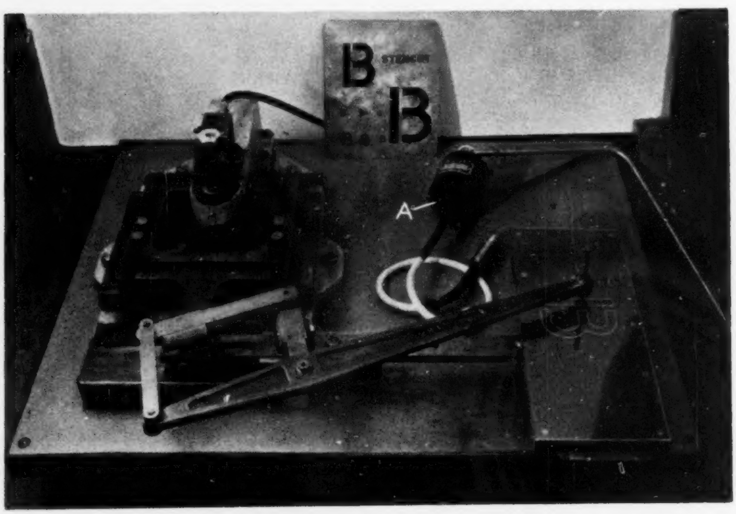
An Air-operated Stencil Cutting Machine

Of patented design, the machine shown in the figure has been developed by Mr. F. C. Heath, 2 Lindley Road, Coventry, primarily for cutting stencils with characters from ⅛ to 6 in. high in sheet metal. A stencil with characters of different sizes which have been cut on the machine may be seen at the rear of the baseplate in the illustration.

Cutting is carried out by means of a spring-loaded punch and a vertically adjustable die, the punch being reciprocated at high speed by a Desoutter air-operated nibbler, which is held in a block secured to a fixed arm. Punches and dies of 0·025 and 0·04 in. diameter are provided. The workpiece blank is mounted on a compound table, the upper and lower portions of which can be moved, in two directions at right angles, on ball-bearing slideways by a pantograph mechanism. An adjustable pantograph may be fitted which gives a reduction between the movements of the stylus pin and those of the table. Alternatively, a pantograph with a fixed ratio of 1 to 1 may be employed.

Apart from stencil cutting, the machine enables profiled shapes and openings of various sizes within its capacity to be produced in sheet metal. It may also be employed for piercing holes in printed circuit boards.

Templates are prepared from transparent plastics material, and they have V-shaped grooves which correspond to the outlines of the characters, or profile shapes to be cut in the work. For the preparation of a template, the plastics sheet is mounted on top of a drawing of the shape to be produced. The V-shaped grooves are then cut with the motor-driven flexible shaft equipment *A*, which, when in use, is suspended in an overhead position from a right-angle support bar. Guide plates are provided for use with this equipment, to facilitate cutting both straight-line and curved grooves in the template.



An Air-operated Stencil Cutting Machine

TRANSPARENT VINYL SHEET FOR MACHINE GUARDS.—A semi-rigid transparent sheet for use in making machine guards, protective screens and windows, has been introduced by Bakelite, Ltd., 12-18, Grosvenor Gardens, London, S.W.1. The new sheet, which is known as Vybak DVB 229, is based on polyvinyl chloride resin, and it is non-inflammable and resistant to water, chemicals and oils. It is said to be extremely resilient and to withstand considerable mechanical abuse without shattering.

Vybak DVB 229 vinyl sheet is available in standard sizes of 50 by 26 in. and 50 by 40 in., and thicknesses of ⅛ and ¼ in., with both surfaces highly polished.

The material can be easily fabricated by the usual methods, and can be assembled by conventional means, with or without a frame. When a curvature or radius is required, it can be formed after the sheet has been warmed.

The Production of Welded Steel Structures for Use in Aircraft*

By B. R. ALSOBROOK†

In view of the increasing demands which are being made on the aircraft and missile industries for structures capable of withstanding high thrust, speed, and temperature conditions, there is a growing tendency among designers to use steel in place of the aluminium alloys hitherto employed. One of the main factors which is exerting an influence in this direction is the difference between the behaviour of steel and aluminium alloys when they are subjected to high temperatures, and this point is illustrated graphically in Fig. 1. Here, a comparison is given of the ultimate tensile strengths of sheet materials, less than 0·25 in. thick, in SAE. 4340 (approximately equivalent to B.S. En.24 steel) and two aluminium alloys—7075-T6 and 2024-TA. It may be noted that, at a temperature of 300 deg. F., the strength ratio of these materials is 2·34 to 1, whereas when the temperature rises to 500 deg. F. this ratio increases to 4·37 to 1. At this point there is no advantage to be gained by using aluminium alloys, but it should be realized that at a temperature of 600 deg. F., and above, the low alloy steels exhibit a high rate of oxidation. Whilst this factor has no great significance for missiles, owing to the relatively short time during which they are subjected to such temperatures, it may well assume considerable importance in the future, when higher performance aircraft are developed and higher strength

* Based on a paper delivered at the S.A.E. Aeronautic Meeting, Los Angeles, Calif., U.S.A.
† Rohr Aircraft Corporation, U.S.A.

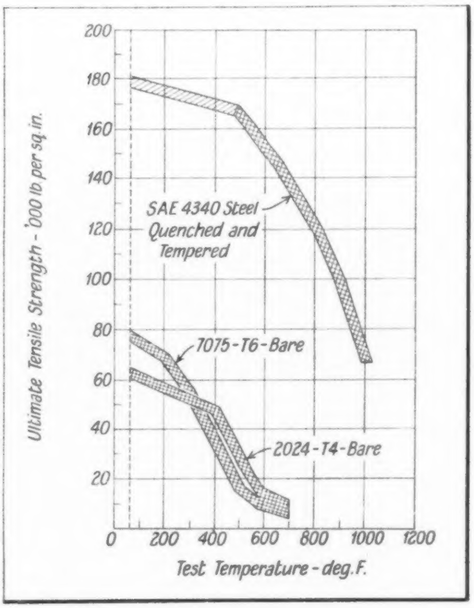


Fig. 1. Curves Showing the Tensile Strengths of Steel and Aluminium-alloy Sheet, Less than 0·25 in. thick, at Various Temperatures. Each Test was Conducted Over a 30-min. Period

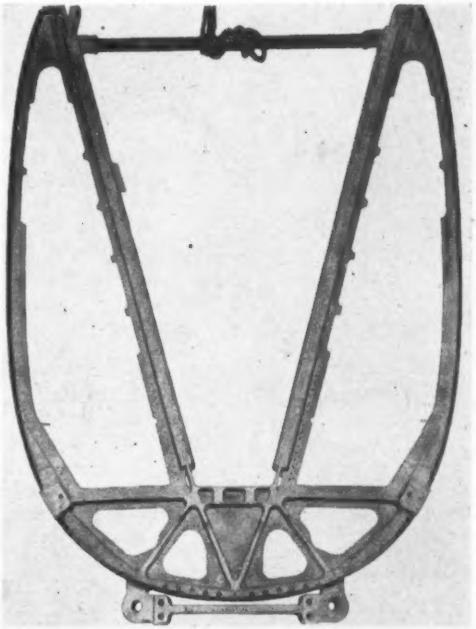


Fig. 2. Fuselage Main Bulkhead Fabricated from Three Basic Parts, Each of Which is a Welded Steel Structure

steel must be employed.

The current design trend towards integral-construction of airframe members has resulted in an increasing transfer of work into the realm of heavy engineering, and it is apparent that the costs and difficulties of machining such parts will increase considerably if these items are now to be made in steel. As a possible solution to these problems, a number of aircraft components are now being fabricated from steel by welding, and it is the purpose of this article to describe some of the methods and designs which have been evolved. Welded structures are generally comparable in cost with machined forgings or castings—and sometimes cheaper—and are their equal as regards strength and weight. Structures of AMS 6434 steel, welded with stainless rod, are heat-treated to 180,000 to 200,000 lb. per sq. in. ultimate tensile strength, with very satisfactory results. In addition, modifications in design can be accommodated more readily with a welded structure, as the alteration or scrapping of expensive patterns or dies is not involved.

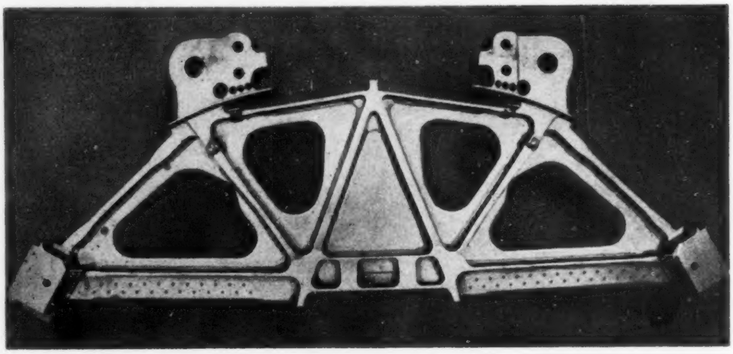


Fig. 4. The Crown of the Bulkhead Seen in Fig. 2. Two of the Flame-cut Spiders Shown in Fig. 3 have been Welded together, with a Steel Plate Sandwiched Between Them

FUSELAGE MAIN BULKHEAD

The largest and most complex welded structure which is at present being produced by the Rohr Aircraft Corporation, U.S.A., is the fuselage main bulkhead shown in Fig. 2. This structure comprises three basic sections, namely, the crown and two V-shaped struts. In Fig. 3 is seen one of the two spiders which form the crown, and these items are flame-cut from steel billets, and then machined. As an example of the continuous design development that is taking place in connection with such structures, it may be noted that, previously, these spiders were assembled from eight separate details, joined by butt-tension welds. However, by using a flame-cut blank, the weight of the part was reduced, owing to the absence of thickened areas for welding, and the time saved by the elimination of the welding and allied inspection stages resulted in a reduction in the cost of the part. The two spiders are welded together, with a steel plate sandwiched between them, but a new design is being prepared in which there is one flame-cut spider piece only, and the webs are inserted separately, and fillet-welded in position.

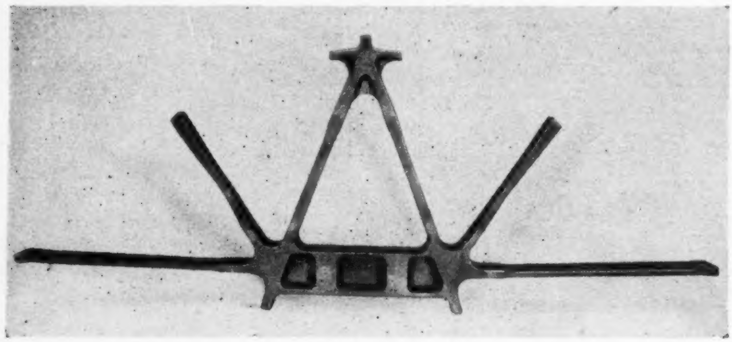


Fig. 3. One of the Spiders which Form Part of the Crown of the Bulkhead Shown in Fig. 2. This Part is Flame-cut from a Steel Billet and then Machined

In Fig. 4 a crown assembly is shown almost completed, only a small amount of welding still being required, and the brackets seen at the right- and left-hand corners are for attaching the finished assembly to the fuselage. A view of the three basic parts, immediately prior to final assembly, is given in Fig. 5, from which

some idea of the overall size of the structure can be obtained. The V-shaped struts are joined to the crown by low-pressure welding, and the complete assembly is then finish-machined, cleaned, and finally plated. At a later stage, the open area of each V-strut is closed by a web, which is attached at the periphery to the vee, also to angle and T-sections inserted between the arms of the vee.

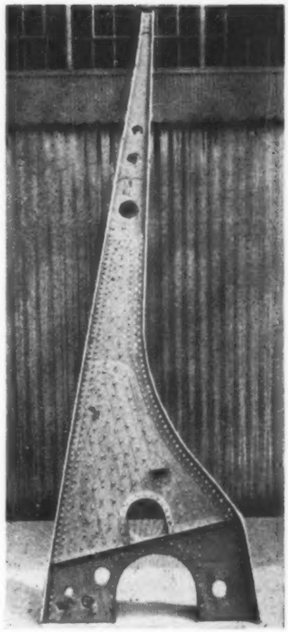


Fig. 6. An Aircraft Flap-track Produced as a Welded Steel Structure. The Track Portions are Flame-cut from a Standard-section Steel I-beam

AIRCRAFT FLAP TRACKS

In Fig. 6 is shown a flap track, which is one of seven different sizes now being manufactured by the company for one aircraft. The double webs between the rails are of 75 ST sheet magnesium, and each rail is of AMS 6434 steel, a different cross-section of rail being required for each of the seven track zones. A basic stage in the construction of this component is seen in the foreground of Fig. 7. A standard I-section beam, from which all track sizes can be fabricated, has been separated in the lengthwise direction by two profiled flame-cuts. This operation is performed on a template-controlled Oxygraph machine, at a cost comparable with that of machining, and with equally satisfactory results. The flange of the I-beam is flame-cut to the required width at a previous stage. Next, the two sections are hot-formed on an H.P.M. press, and after the edges which are to be welded have been machined they are brought together as seen at *A* in Fig. 7, where the parts are shown turned, end-for-end. The prepared edges are then welded together, in one pass, on a submerged-arc machine, and the assembly after this stage can be seen at *B* in Fig. 7, with a flat section tie-member also welded in position. After welding, the entire assembly is heat-treated to 180,000 to 200,000 lb. per sq. in. ultimate tensile strength in a molten salt bath, this process having been adopted because it ensures minimum distortion and de-carburization of the surfaces.

In Fig. 8 can be seen the alignment-checking fixture on which the part is inspected after the heat treatment process, and here, also, the extent of the hot-forming and welding operations is clearly indicated. If the part is within the specified limits, it is transferred, still in the checking fixture, to a radial machine, on which various tooling holes are drilled. At the next

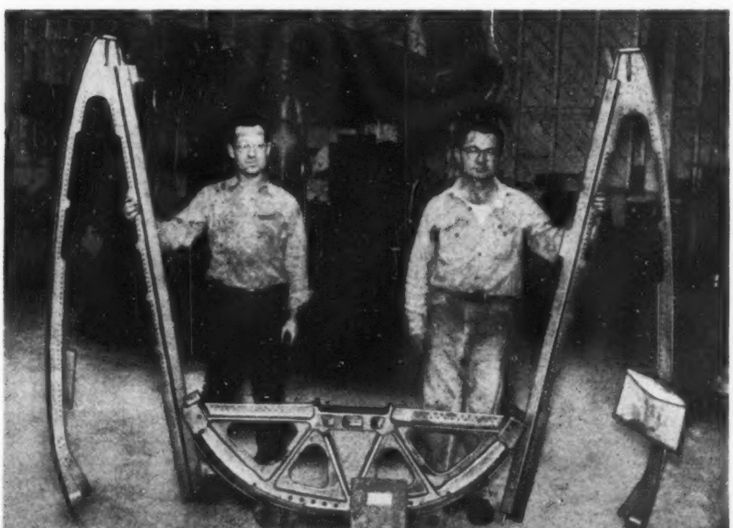


Fig. 5. The Three Basic Parts of the Fuselage Bulkhead Ready for Final Assembly. The Open Area Between the Arms of Each V-strut is Subsequently Filled-in with Aluminium Sheet and Cross-members

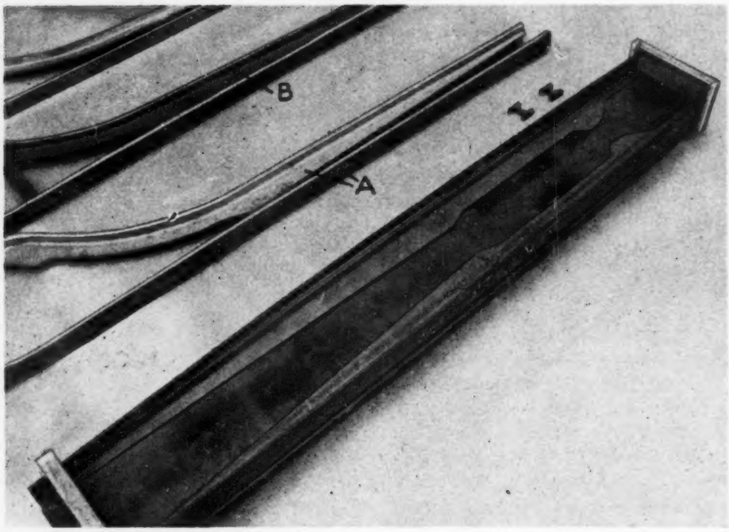
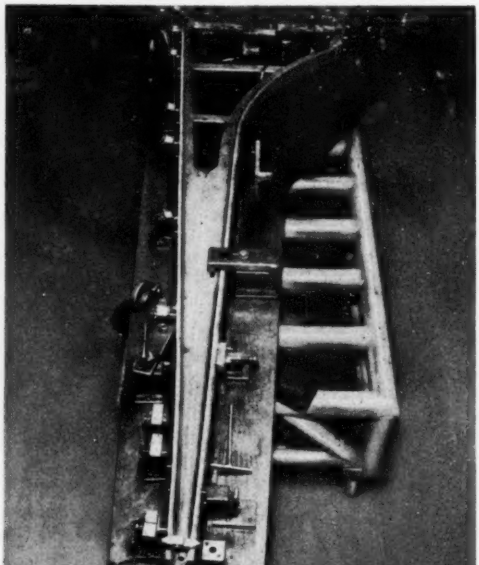


Fig. 7. A Basic Stage in the Manufacture of the Flap-track Seen in Fig. 6. A Standard-section I-beam has been Separated in the Length-wise Direction by Profile Flame-cuts to Produce the Two Track Members. After Hot-forming, the Parts are Assembled as Seen at *A* and Welded Together, as at *B*

Fig. 8. (below) An Alignment-checking Fixture for the Flap-track Seen in Fig. 6. The Extent of the Hot-forming and Welding Operations can be Seen Clearly



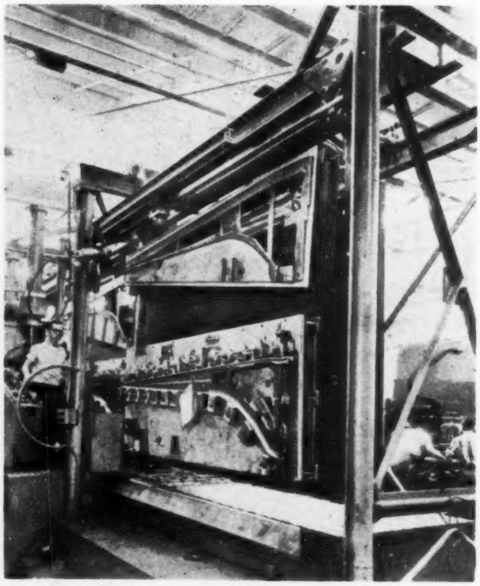


Fig. 9. The Flap-track is Mounted on this Vertically-suspended Transfer Plate Prior to Milling the Tracks and Webs on a Sundstrand Machine

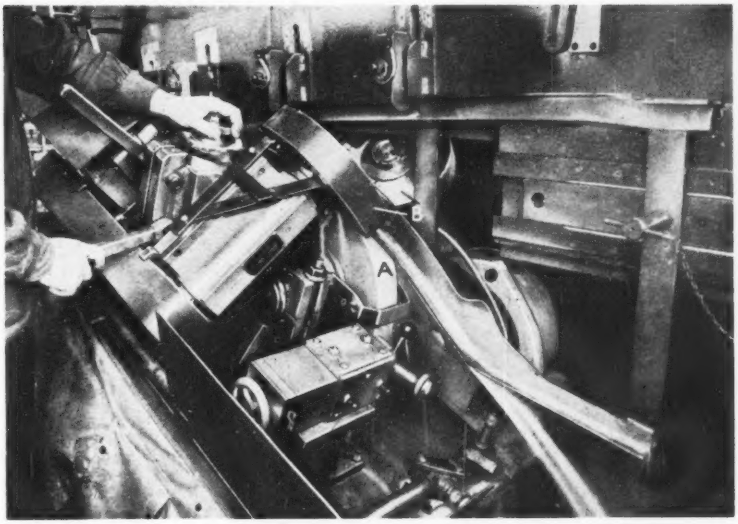


Fig. 10. A Mattison Machine has been Modified for Grinding the Previously-milled Tracks. One Wheel *A*, and the Two Angularly-disposed Wheels *B* are Used for Grinding the Outer and Inner Track Surfaces Simultaneously

stage, the tracks and webs are milled on a Sundstrand machine, and for this operation the part is loaded into the vertically-suspended transfer plate shown in Fig. 9. The Sundstrand machine is controlled by a template and magnetic tracer, and is used for finish-machining the webs, and rough-machining the tracks, in preparation for a subsequent grinding operation.

For grinding one outer, and two inner surfaces of each track, simultaneously, the company has adapted a Mattison machine, and a close-up view of the grinding operation on the curved track is given in Fig. 10. The part is held in a vertical fixture by means of the clamps seen at the top of the illustration, and the heel of each clamp makes contact with a sloping face on the locating block, thus ensuring that the part is pulled firmly against the latter. A locating plunger, seen at the right of the figure, is used to engage one of the previously mentioned tooling holes, and a similar means of positioning the component is used in the fixture for the milling operation seen in Fig. 9.

WELDED ENGINE MOUNT

To facilitate a welding operation, and to ensure the necessary quality of the joint, it is preferable to weld in the horizontal plane, and to this end the company employs, wherever possible, adjustable welding fixtures. A typical example of a large welding fixture is shown in Fig. 11, where the

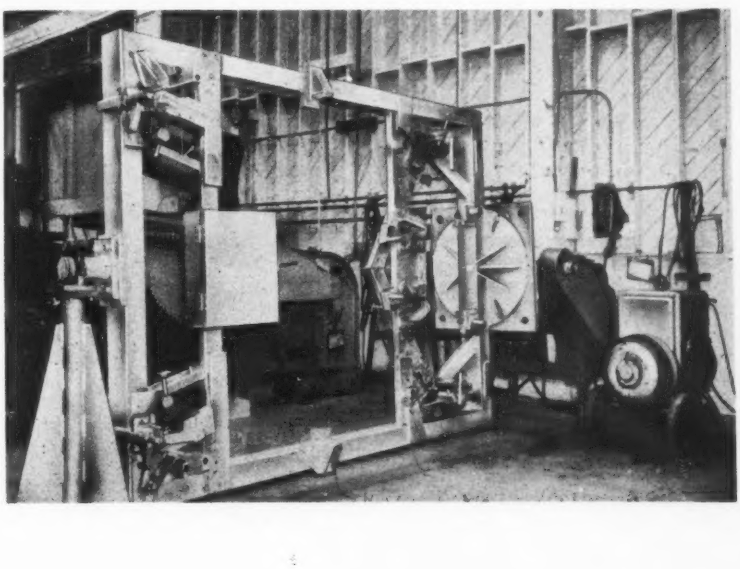


Fig. 11. A Typical, Large, Trunnion-mounted, Welding Fixture which can be adjusted to Permit Welding to be Performed in the Horizontal Plane

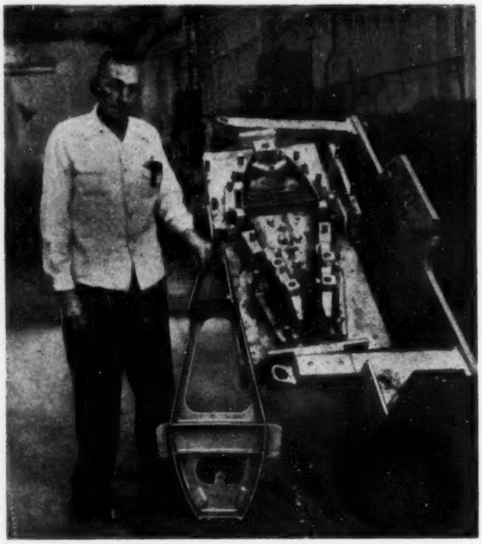


Fig. 12. This Trunnion-mounted Welding Jig is Carried on a Pivoted Fixture. The Jig is Loaded with a Welded Steel Front Engine Mount Similar to that Being Held in the Foreground

main frame is trunnion-mounted on two fabricated pillars. The smaller, rotating fixture, in Fig. 12, carries a trunnion-mounted jig, in which an engine mount bracket is seen loaded, and a finished component is being held in the foreground. The flat lugs seen projecting from each side of the workpiece, in line with the two transverse ribs, are steel forgings, and they are slotted to engage with the main sheet steel web, to which they are welded. Another forging is used for the tapering portion, at the top of the component, and is attached to the web by welding, in two passes, at the second operation, the first weld pass being ground to remove all surface slag before the second pass is made. Finally, the side plates, the transverse ribs, and the thickening pieces seen at the lower end, are attached.

This workpiece is a front engine mount, and to produce such a highly-stressed part, of the equivalent weight, from a one-piece forging, would require a considerable amount of expensive machining, and time. By using small forgings, sheet and plate, this component is fabricated successfully at a comparatively low cost.

Further examples of welded steel structures for aircraft are shown in Fig. 13, also another view of the front engine mount previously described. In the foreground is seen a bracket which is fitted in the strut of a jet pod, and serves as an aft support point for two J-57 jet engines. The parts being held in the background of Fig. 13 are torque segments for aircraft bulkheads, the longer piece being used as an inboard strut. Three premachined forgings are employed for this structure, namely, an upper and a lower segment, and a centre piece complete with attachment lugs. In general, it is found that gas-welding is suitable for most fillet-welding applications, whereas arc-welding is employed for all butt-joints. The faces to be butt-jointed are machined square, or slightly chamfered to form a narrow vee, and are assembled with a space between the two edges. To ensure complete penetration in a butt-joint, backing pieces are tack-welded in position, behind the joint, prior to the welding operation.

A trunnion-mounted jig is used to hold the workpiece, and the close-up view, Fig. 15, shows the three parts in position and prepared for welding, with the chill-bars tacked in place. After

Fig. 13. Typical Examples of Welded Structures Employed in Aircraft Construction. The Part in the Foreground is an Aft-support Bracket for Two Jet Engines. In the Centre is Another View of the Front Engine Mount Seen in Fig. 12, and the Parts Being Held at the Rear are Torque Segments for Bulkhead Fittings

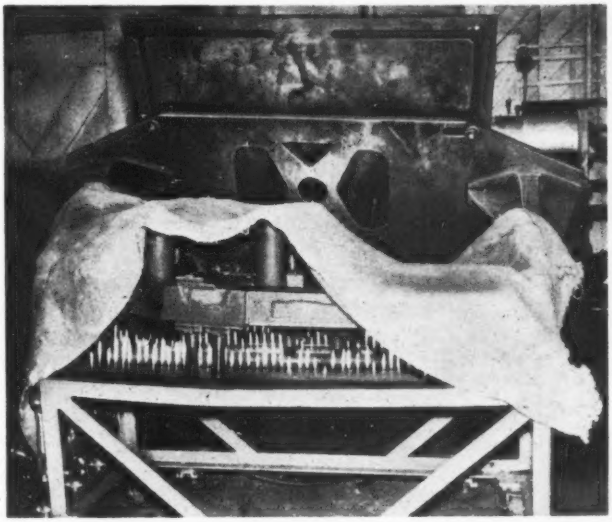


Fig. 14. A Mobile Gas-burner in Position Beneath a Welding Jig. These Burners are Used to Pre-heat the Mass of the Jig and Workpiece Prior to the Welding Operation. The Jig is Covered by an Insulating Blanket During the Pre-heating Period

the final welding, which is preceded by a pre-heating period, the chill-bars are machined away, and the part is transferred to a heat-treatment fixture. As these torque segments are fabricated from pre-machined forgings, it is essential that the stress-relieving and tempering processes should be controlled closely in order to ensure the minimum distortion, and it is found possible, in practice, to hold this workpiece to within a tolerance of 0·010 in.

PRE-HEATING FIXTURES AND WORKPIECES

As has been mentioned previously, the welding operation is preceded by a heating period, during which the welding jig and the workpiece are raised to temperatures of the order of 350 to 450 deg. F. Heating may be performed in an oven, or by means of a mobile gas-burner, and an example of the latter method is shown in Fig. 14. Here, a trunnion-mounted fixture has been adjusted so that the bank of gas-burners can be wheeled into position beneath the welding jig. At the end of the pre-heating period, the gas-burner is removed, and hand torches are used to keep the mass of the jig and workpiece at the required temperature while welding is taking place. The temperature is checked frequently, and it has been proved that the pre-heating process minimizes thermal shock, and prevents embrittlement of the weld area.

An actual welding operation is performed in accordance with a predetermined sequence, from which the welder is not allowed to deviate. In the case of multi-pass welding, each weld bead is thoroughly cleaned, by grinding or other convenient means, before the next pass is made. If, for any reason, the welding is interrupted before it is completed, the workpiece and its fixture are transferred to an oven, where the pre-heat temperature is maintained until welding can be resumed.

After the welding sequence has been completed, the fabrication is raised to a temperature of 350 to

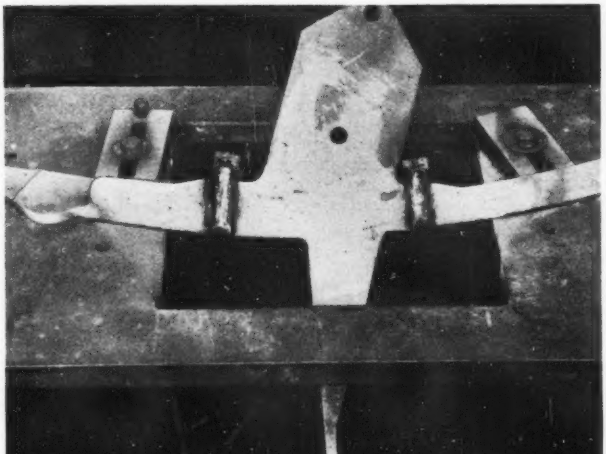


Fig. 15. Close-up View of One of the Torque Segments Seen in the Background of Fig. 13. The Part is Held in a Trunnion-mounted Jig and the Backing Pieces have been Attached Prior to the Main Welding Operation, and are Machined away After Welding

600 deg. F., prior to the stress-relieving process. Transfer to the stress-relieving furnace must take place rapidly, in order to avoid any appreciable loss of heat, and, once in the furnace, the part is raised to a temperature of 1,200 deg. F., for a minimum period of 20 min. The final heat-treatment takes place in a salt bath furnace, this process being preferred to controlled atmosphere furnace treatment because the heating is effected more rapidly and uniformly, with the minimum distortion, and because it has a cleaning action on the workpiece.

INSPECTION

A welded structure receives its last inspection check immediately prior to the final surface finishing of the parts and its subsequent installation in the aircraft. Close radiographic inspection control is maintained on all workpieces, to ensure the necessary high quality, but the precise interpretation of a radiograph, and assessment of the significance of flaws, are problems which still remain to be resolved satisfactorily. One of the most important decisions which must be made, after radiographic inspection, concerns the extent to which any particular flaw will affect the structure from the point of view of fatigue. This factor is of obvious significance in relation to parts for aircraft, and the company has conducted a series of experiments in which the effects of various imperfections on the fatigue-resisting properties of high-strength AMS 6 435-502 steel have been studied. From the results obtained so far, it would appear that internal defects as large as $\frac{1}{32}$ in. have no greater effect on fatigue strength than does the surface condition of the parent metal after normal production processes. Another series of tests will therefore be carried out, to determine whether surface finish, or weld defects is the limiting factor as regards the fatigue-resisting properties of a welded structure.

Now that welded components have been incorporated successfully in aircraft, it is apparent that increasing use will be made of this method of construction in the future. The method also appears to be suitable for the construction of missiles, and the following notes are relevant to both these applications.

1. Welded construction offers the advantage of adaptability in design, and modifications can be effected without incurring considerable expense and interruption of production flow.

2. If welded components are to be used, then the designer must work in close co-operation with the production department, so that the individual requirements of each may be satisfied.

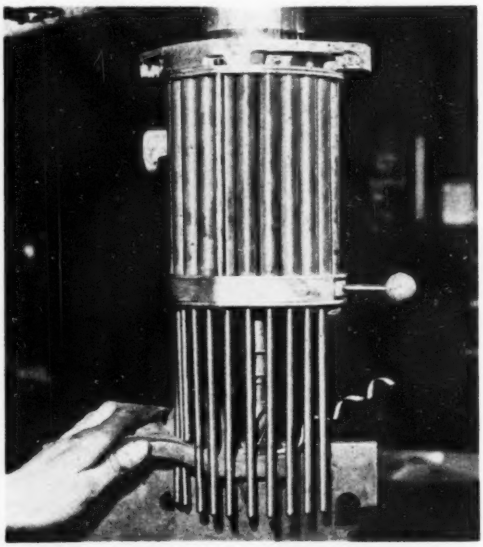
3. With the present quality of the company's production welding and radiographic inspection, it is apparent that the allowable loading of 80,000 lb. sq. in. (120,000 lb. sq. in. ultimate) can be increased by an amount ranging from 19,000 to 40,000 lb. sq. in.

4. In estimating the fatigue life of a welded structure, the condition of the surface-finish of the parent metal, after such processes as plating, de-scaling and grinding, must be considered, in addition to any imperfections in the weld.

Newton Chambers Guard for Radial Drill

The guard shown in the accompanying illustration was designed by Mr. L. Crookes, mechanical maintenance engineer with Newton Chambers & Co., Ltd., Thorncliffe, Sheffield, and has been patented by the company. It has been tested in the machine shops of the engineering division and is being put into production.

Arranged for attachment to the spindle sleeve, the guard comprises a number of spring-loaded rods which can telescope when they come in contact with the work surface. It is claimed that the guard provides full protection for the operator without obstructing his view of the drill, and does not cause swarf to accumulate.



Newton Chambers Guard for Radial Drill

Broaching Internal Helical Gears

By F. KIRSTEN*

The successful production of internal helical gears of the order of 6 in. pitch diameter and 14 D.P., by the broaching process, has resulted in important economies. The gears can be rough- and finish-broached, and held to close tolerances without subsequent tooth-finishing operations.

A typical internal helical gear of about this size is being mass-produced by the broaching method to the following tolerances: circular tooth thickness, 0·001 in.; involute profile, 0·0004 in.; tooth-to-tooth spacing, 0·0005 in.; accumulated tooth-spacing error, 0·0008 in.; and lead, 0·0005 in. per inch of face width. The inside diameter of the gear blank is bored to a tolerance of 0·004 in. prior to broaching. One motor-car transmission factory is producing 5,000 gears per day by rough- and finish-broaching operations. Five broaching machines are used, as compared with the 67 machine tools required for the conventional gear-generating method previously employed.

The key to success with this type of gear-machining operation lies in the co-ordination of the design, production, and quality control necessary to provide precision broaches up to 7 ft. long, and weighing up to 600 lb. Special precision machine tools, heat-treating furnaces, and inspection equipment have been developed for producing solid broaches of the necessary size and accuracy.

BROACH REQUIREMENTS

For an internal gear broach there are two basic requirements: it must be accurate as regards tooth size, form, spacing, and lead; and it must provide the maximum wear life.

Accuracy—Broaches for internal gears must produce teeth of involute form which are accurate to $\pm$0·0002 in.

To ensure maximum involute profile accuracy, the teeth are ground from the solid after the broach has been heat-treated. By performing the tooth-grinding operation at this stage, heat-treatment checking which sometimes occurs at the roots of the teeth, and problems due to scale formation, are avoided. Another difficulty may arise when the involute teeth of broaches are rough-milled in the soft state. Frequently, more stock is removed from one side than the other during the grinding operation after heat-treatment, because of indexing errors in the rough-milling, or distortion caused by heat-treatment. As a result, one side of a finished tooth may be softer than the other.

One advantage of the broaching process is the ability to modify the involute form on the driving or over-run sides of the teeth, or both. A precision master template in the wheel dressing unit

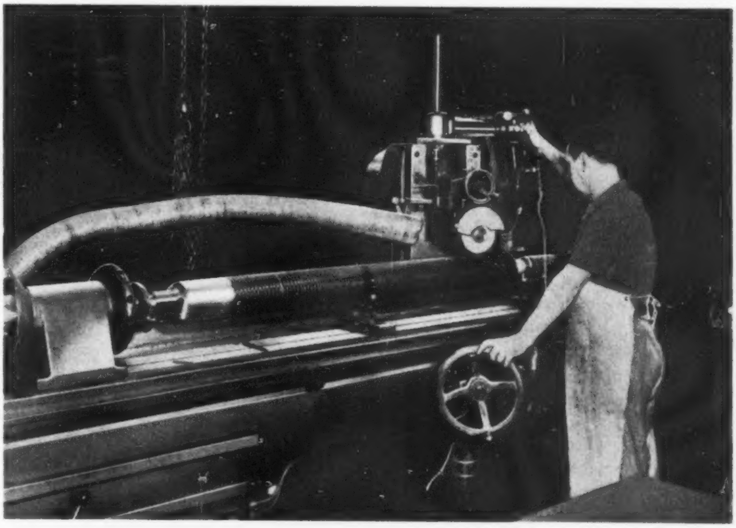


Fig. 1. An Involute Form, with the Required Accuracy of Modification, is Ground from the Solid, in a Heat-treated Broach Blank. A Precision Master Template in the Dressing Head Ensures the Correct Grinding Wheel Profile

* National Broach & Machine Company, U.S.A.

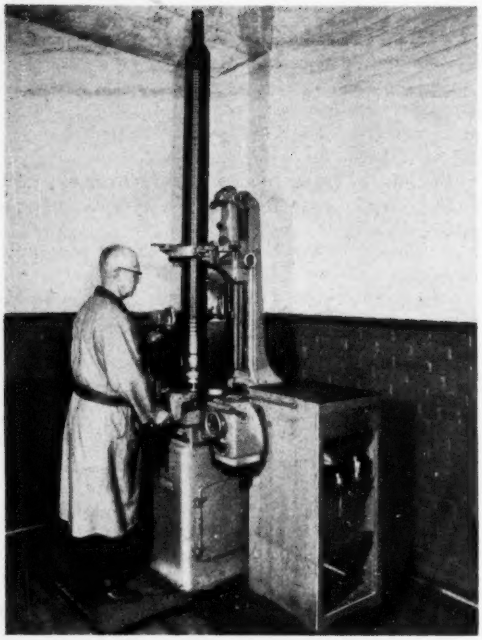


Fig. 2. The Accuracy of the Gear Tooth Form on the Broach is Inspected on a Special Involute-profile Checking Machine with Reference to a Master Base Circle

on the special spline grinding machine shown in Fig. 1 ensures that a true, or modified, involute form of the desired accuracy is faithfully reproduced on the grinding wheel. Accuracy of the finished broach is checked on the special Illinois involute-profile inspection machine, shown in Fig. 2, which incorporates a master base circle.

Uniformity of tooth space and helix angle accuracy as between one gear and another is ensured by the broaching method. Production of the broach lead during the spline-grinding operation must, however, be accurately controlled. The grinding machine shown in Fig. 1 has a specially designed lead-bar arrangement that enables the desired results to be obtained. The lead-bar rotates the broach through a no-backlash drive while the splines are ground one at a time. Accuracy of the lead-bar, and of the lead of any tooth on a broach, is checked on a specially designed lead-checking machine installed in a sound-proof, air-conditioned laboratory.

Spacing accuracy is achieved during spline-grinding by means of a high-precision automatic indexing mechanism. Accuracy of spacing is very important in a gear broach.

Tool Life.—Maximum wear life for gear broaches is ensured by providing uniform lands of maximum length. To ensure that the lands are accurate for length and uniformity, the tools are inspected after the land-turning operation.

Since the broach blanks are long and comparatively slender, yet of considerable weight, special heat-treatment equipment and procedures are necessary. To enable a uniform hardness of 63 to 65 Rockwell C to be obtained along the entire length of the blank, both low- and high-temperature deep-pit furnaces—each providing three individually controlled temperature zones—are used.

Great care is taken in straightening the broach blanks after heat-treatment. If straightening is carried out at the correct temperature, the broaches will remain straight during the subsequent grinding operations and throughout their service life.

Material for gear broaches is selected for edge toughness, abrasion resistance, ease of grinding, and heat-treatment characteristics. As a rule, AISI Type T-1 hot-rolled steel bar stock, with the correct grain formation and carbide distribution, is employed.

Considerable improvements in broach life can be obtained by applying certain surface treatments. For example, the Naloy surface treatment minimizes side-loading of the teeth by providing a high skin hardness that resists abrasion, and ensures complete transformation of the broach material to an optimum martensitic structure.

Some manufacturers of internal gears prefer to semi-finish broach the teeth and then finish them on a rotary gear-shaving machine. If this procedure is to be followed, clearance should be provided at the roots of the semi-finished gear teeth to accommodate the tips of the shaving cutter teeth. Provision can be made for this clearance at the spline-grinding operation by suitably modifying the form of the master template for the wheel dresser. Similarly, the internal gear teeth can be chamfered at the tips, if required.

CUTTING INTERNAL HELICAL GEARS BY 2-PASS BROACHING

One of the most economical methods of producing internal helical gears is by 2-pass broaching, and no subsequent tooth-finishing operations are then required. This method is employed by the Warner Gear Division of the Borg-Warner Corporation in the manufacture of automatic and over-drive transmissions for automobiles.

One of the ring gears for an over-drive transmission is shown in Fig. 3, at its various production stages, together with the roughing and finishing

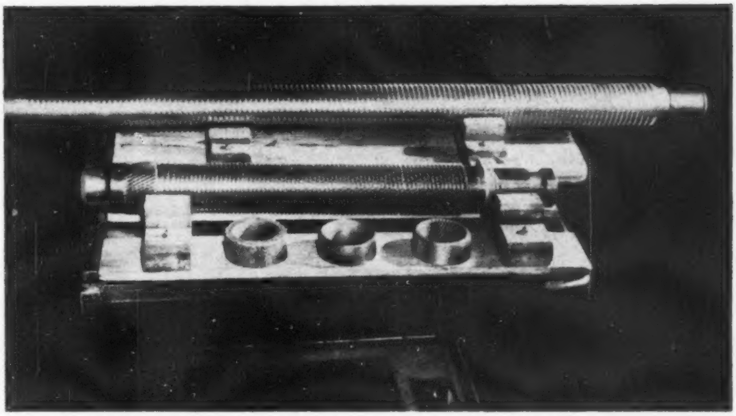


Fig. 3. Three Stages in the Production of a Helical Ring Gear for an Over-drive Transmission. A Roughing Broach (rear) and a Finishing Broach (front) were Used

Red Ring broaches which were employed to cut the internal teeth. The gear blank is machined from a steel forging, in readiness for the rough-broaching operation. Two of these 42-tooth, 14-D.P. gears—with a pressure angle of 20 deg. and a helix angle of 27 deg.—are cut simultaneously on the 2-station pull-down type American Broach machine shown in Fig. 4. Helical teeth are produced by rotating the broaches as they are pulled through the part. To provide the required rotation, a single helical lead-bar is located in front of the broaches, as may be seen in the illustration. The roughing broaches are about 6 ft. long by 3¾ in. diameter at the largest point. Involute forms on the opposite tooth-faces have different modifications.

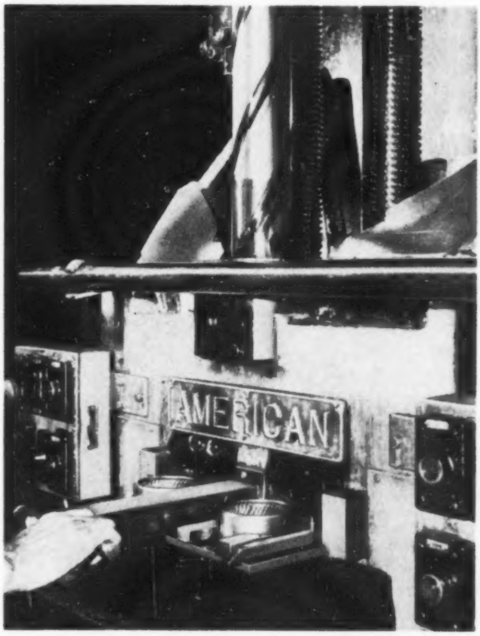


Fig. 4. Two of the 42-tooth, 14-D.P. Ring Gears are Rough-broached Simultaneously on this Pull-down Type Machine. The Helix Angle is Controlled by a Single Lead Bar which Rotates the Broaches as they Descend

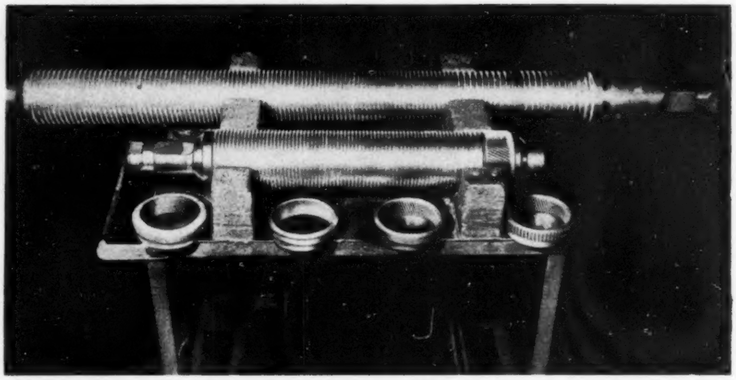
WORK LOCATION FOR FINISH BROACHING

Finish-broaching is carried out on one gear at a time on a single-ram, American Broach push-down type machine. The operator slips the part over a helical gear guide, which is machined on the pilot portion of the 3-ft. long broach, seen at the front in Fig. 3. A spring detent is provided to hold the gear in place until it is moved down and seated in the work-nest. The broach then passes through the gear and finishes the teeth. With this arrangement, accurate alignment is ensured between the rough-cut teeth in the gear and the finishing teeth of the broach.

Another part which is being produced at the Borg-Warner works is a ring gear for an automatic transmission clutch. This component is larger than the gear already described—having a diameter of 6 in.—and there are spur gear teeth on the periphery. The 15-D.P. internal gear, which has 72 teeth, a 17½-deg. pressure angle, and a 22-deg. helix angle, must be machined concentric with the 59-tooth, 10-D.P. 20-deg. pressure angle spur gear. The roughing and finishing broaches employed to cut the internal teeth, together with parts at various production stages from the rough forging to the finished gear, are seen in Fig. 5.

The rough-broaching operation is performed on two parts at a time on another 2-station pull-

Fig. 5. These Broaches are Employed for Rough- and Finish-cutting 72 Helical Teeth of 15-D.P. in a Ring Gear for an Automatic Transmission Clutch



down-type of broaching machine. A helical lead-bar again controls the rotation of both the 6-ft. long by 5⅝-in. diameter broaches as they are pulled through the gear blanks. After this operation, the gear is located from the internal teeth and the external spur teeth are machined on a Shear-Speed shaper. By following this procedure, the maximum amount of metal is removed from the ring gear prior to the precision finish-broaching operation, which is carried out on a single-ram, push-down machine.

A helical starting guide for the gear is again provided on the pilot end of the 3-ft. long finishing broach, and the gear is retained on the guide by a spring detent.

Career Horizons

Some Foreground Features which Help to Spoil the View

By a Correspondent

The recent appearance of a full-page displayed advertisement, measuring some 22 by 16 in., in a national newspaper, devoted, not as one would expect to the sale of the advertiser's engineering products, but to a statement of the firm's needs for workers in many departments, would come as a shock to anyone of a generation which remembers the time when all that was needed to bring in several hundreds of applications was a simple 2-line advertisement, in a "situations vacant" column, on the lines: "Draughtsman wanted, accustomed to detailing, Box X . . ." In those days, the lure of even such a bald intimation was so great that many engineering concerns would not allow trade publications to be circulated amongst their staff until these temptations had been deleted from the copies intended for general reading. Today, it is certain that an announcement on these lines would not bring a reply, and "situations vacant" have progressed from their former lowly position in the "smalls" section, to a stage at which they provide considerable advertising revenue.

In spite of the 1-page example mentioned, however, English employers have not yet reached the stage of desperation to which their American counterparts have been reduced. In the United States, for a number of years past, the trend has been towards illustrated full-page and half-page announcements, and certain of the technical publications have added both to their revenue and reader-interest by including them in so-called "career horizons" supplements, in which talented artists and clever psychologist copy writers combine to tempt the worker. One such advertisement, for instance, will feature a "contemporary 25,000-dollar home (i.e., "house") and carry as a caption the conceit-deflating question: "Technicians, does your present job offer you such a home after two years' work? If not, write us." An aircraft firm, in a regular series, will one week show a care-free worker fishing by the side of a pleasant lake. The next week he will be shown on a shooting expedition, riding, sailing, or camping, to indicate the way of life which is apparently enjoyed by its fortunate workers. Captions inform the reader: "it could happen to you," "ability shows up fast in our works," or "two years ago —— ——, our works manager, joined us as a trainee."

Against the attractions of such dream pictures,

how hum-drum are the methods, and how small the inducements, which an English employer offers, even making full allowance for the 5-day week, the pension scheme, and the canteen facilities, as well as the rarer non-committal hint of a "good salary."

Moreover, the net results even of the most successful of these attempts are apt to be diminished sadly when there is interposed, between the applicants and the final selector, a personnel officer with a passion for uniformity and a flair for psychology. Let us consider the imaginary case of a manufacturer of dolls-eye machinery who advertises for a designer who "must have had considerable previous experience in this line." Even the most promising application, from a man who states that he has already been solely responsible for the design of the *A*, the *B*, and the *C* makes of machine, but is anxious for a change, would stand little chance of securing any worthwhile attention or effective action.

He would be met merely with a request for the completion of a 4-page or 6-page application form which would probably demand his Christian names in full; number of brothers and sisters; whether married or single; number of children; whether living (*a*) with relatives, (*b*) in a shared flat with friends, (*c*) in lodgings, (*d*) in a house, and, if so, whether it is owned, partly paid for, or rented. Next, his medical history would be required, with a list of his illnesses and operations, the name of doctor or surgeon in each case, and the date. Details of his education requested would include names of all schools, college, or university, whether part-time or full-time, and passes, certificates or degrees secured. He would also be asked to give particulars of professional associations of which he was a member, and his exact status in such associations; previous employers (working backwards), with dates, exact descriptions of positions held, earnings in each, and reasons for leaving; religion professed; clubs and societies of which he was a member, and finally, his hobbies—does he read, does he attend the cinema, the theatre, and so on?

It is a document which never contains less than four pages of questions, and if a man has any independence of character it can usually be guaranteed to dissuade him from risking any further contact with a concern afflicted with so much morbid curiosity.

Even if a candidate has brought himself to the pitch of supplying all these personal details, however, his difficulties and perplexities are by no means over. Should the answers be given in handwriting or typewriting? The busy engineer or executive, it is true, prefers the typewritten communication as being far easier to read and to handle. A personnel officer, on the other hand, usually prefers handwriting, for the reason that he is something of a psychologist, and firmly believes that he possesses the gift of being able to assess a man's character, qualities, and abilities from his writing. If this happens to be good and clear, the writer would be of a somewhat lowly status, probably an underpaid clerk or book-keeper. If, on the other hand, it is bad, it indicates slovenliness, a disordered mind, and general incapacity.

On the other side of the Atlantic, the applicant may next have to face the ordeal of a "personality questionnaire" (or quiz), containing anything up to 125 questions on the lines of: "Do you give money to beggars?" "Do you consider matters carefully before making a decision?" The answers to these questions, it is stated, will enable a personnel officer of experience to prepare a graph which shows whether the applicant is neurotic or stable, whether he has drive or is of the quiet type, sociable or unsociable, and so on.

From the United States comes also the psychological test, which although it has been fully described in the English Press does not appear, so far, to be widely used on this side. Briefly, a blot of ink is made in the middle of each of ten sheets of paper, which are folded over while the blots are still wet. To some of these sheets a splash of colour may be added. An applicant for a post is invited to say what he sees in these blots. The writer regrets that he is unable to give any advice to those who may, in the future, be faced with such a test, as it is stated by the originators that the system can only be used by trained specialists. It would, however, not betray the secrets of the craft unduly to remark that when a sheet is encountered with a sudden splash of red colour, an applicant who is at all neurotic is supposed to be so shocked by the sudden change of colour that his mental processes come to a complete stop. Even the reaction of an intelligent man that the system is too childish to be pursued, is darkly asserted to "indicate something of importance concerning his mental structure," which can be suitably interpreted by a specialist in these matters!

It used to be generally believed in the technological world that it was easier for a person to double his salary by changing his employer than to obtain a further five shillings a week advance by staying where he was. In spite of the more seductive phrasing of the latest type of advertisement, few would be prepared to deny that the candidate who has overcome the barriers of a modern management questionnaire and test richly deserves his increased emoluments.

Industrial Technics Co-ordinate Drilling Machine with Automatic Positioning

The first co-ordinate drilling machine built by Industrial Technics (Southampton), Ltd., Empress Road, Southampton, shown in Fig. 1, was described briefly in MACHINERY, 91/715—20/9/57. For this machine, the E.M.I. numerical control system, incorporating Farrand Inductosyn units, is employed for positioning the compound work table, and an accuracy of ±0·0002 in. is claimed. It may be recalled that this positioning system was the subject of an article in MACHINERY, 90/1062—10/5/57. Industrial Technics are also arranging to supply co-ordinate drilling machines equipped with an alternative method of table positioning, namely, the Ekco machine-tool control, which has been developed and produced by Ekco Electronics, Ltd. This equipment may be fitted to existing machine tools, and is described later in this article.

To ensure that friction on the slideways is reduced to an almost negligible value, the carriage and table of the co-ordinate drilling machine are supported on Thomson re-circulating ball bushes, which move on hardened and ground cylindrical guides. A pre-load of 600 lb. is applied to each bush, and the guide is hardened to Rockwell 60 C. Under these conditions, the coefficient of static friction of each ball bush, when carrying the full load, is approximately 0·003. Four bushes are provided on each side of the carriage, as indicated at *A* in Fig. 2, and there are three bushes on each side of the table, so that there are 14 in all. The ball bushes are of the type described in MACHINERY, 91/1394—13/12/57. They are not completely cylindrical, but have longitudinal gaps in the walls to clear the guide bar mountings, as will be seen from the end elevation. The round bars, with which the carriage ball bushes engage, are 48 in. long by 1½ in. diameter, and each is mounted on four machined blocks, which are bolted to the fabricated bed structure. The bars have drilled and tapped holes, whereby they are secured to the supporting blocks. A similar arrangement is provided for the movement of the table on the saddle, and one of the guide bars for the table is indicated at *P* in Fig. 2.

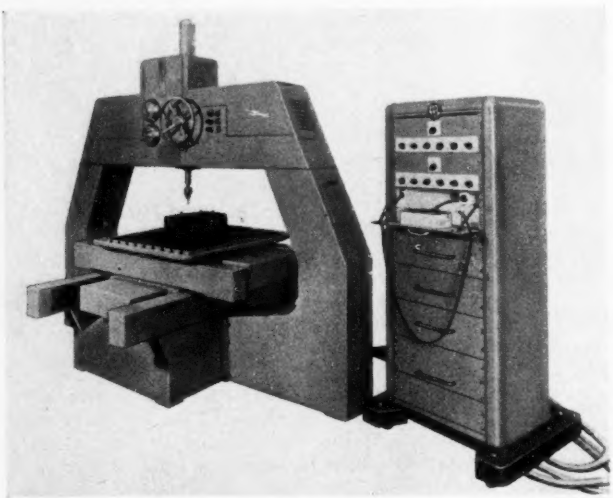


Fig. 1. A General View of the Industrial Technics Co-ordinate Drilling Machine with E.M.I. Control System for Automatic Positioning

SOLENOID-OPERATED CLAMPS

A split clamp *B* is provided for each guide bar, and is operated by a solenoid *C*, through a linkage. The inner portion of each clamp is connected to the table (or carriage) by way of a flat spring, so that the clamp can float during the traversing motion. When the table (or carriage) comes to rest, in the required position, a relay in the control circuit energizes the solenoids, and the clamps are engaged, the gripping pressure applied by each being 450 lb. A time delay is incorporated to ensure that the clamps are not engaged in the event of zero voltages occurring, momentarily, during the positioning cycle. Limit switches, connected in the servo-motor circuits, prevent over-running of the table.

Special precautions have been taken to exclude dirt and dust from the slideways and Inductosyns, one of the latter units being seen at *R* in Fig. 2. Flexible metal bands,

0·010 in. thick, carried on vertically mounted pulleys, encompass the slideways and follow the movements of the table and carriage. Felt linings between each metal band and the top cover, also between the band and the portion of the table (or carriage) on which the mounting blocks are supported, complete the enclosure of the slideway system. Mechanical protection for the dustproofing bands is provided by sheet metal covers, one of which may be seen at *D* in Fig. 4.

Reduction of friction and back-lash in the gearbox has received special attention, and hardened and ground screws with pre-loaded re-circulating ball nuts are employed for traversing the carriage and table, the nut for the table being indicated at S in Fig. 2. Bellows are fitted to provide a dust-proof enclosure for each lead screw. A sectional view of one of the gearboxes is shown in Fig. 3, and it will be observed that the shafts are mounted in angular-contact and plain ball-bearings.

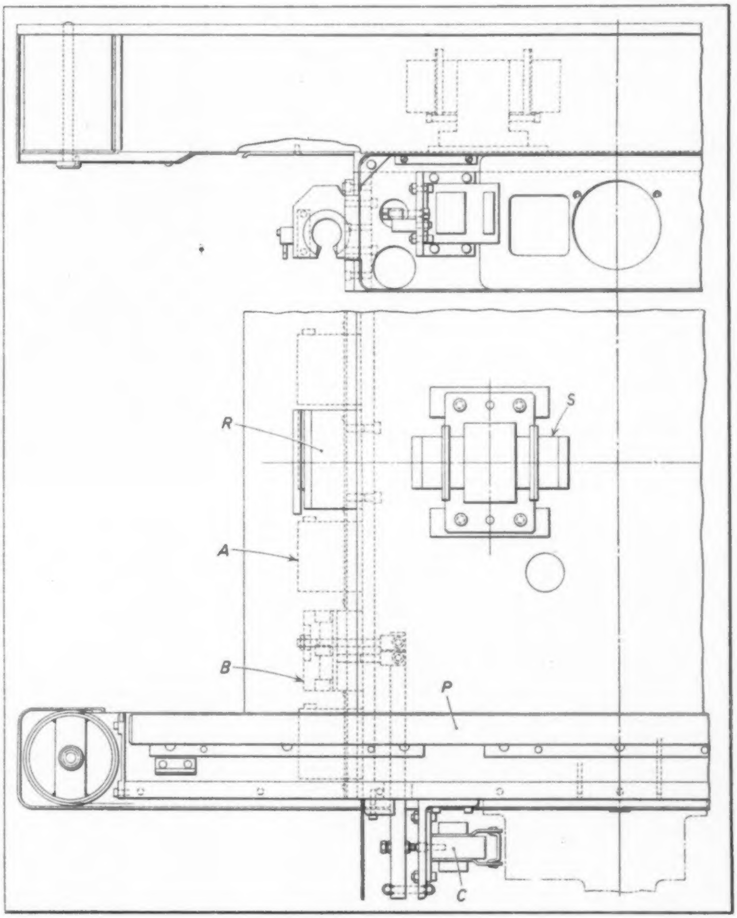


Fig. 2. Arrangement of the Carriage of the Co-ordinate Drilling Machine, Showing the Round Guide-members, Re-circulating Ball Bushes and Solenoid-operated Clamps

The principal gears, indicated at *E* and *F*, are of a special sandwich construction, whereby back-lash in the train is virtually eliminated. These gears are made from laminated blanks, each consisting of a layer of nylon, which is held under pressure between two outer layers of bronze, the whole assembly being riveted together. After completion of the gear cutting operation, the nylon lamination of the assembly swells slightly, so that it becomes somewhat larger in diameter (approximately 0·0005 in.) than the outer metal layers. This expansion of the nylon suffices completely to eliminate play between the meshing gears. The same principle of sandwich construction is used for the wormwheel incorporated in the drive to the resolver, which is taken from the worm *G*. Due to the low frictional resistance of the slideways and gear trains, the power required for the traversing mechanism is small, and well within the capacity of the ⅙-h.p. servo motor employed. The 40 to 1 reduction gearing provided gives a table traverse speed of 60 in. per min.

Overheating of the servo mechanisms is prevented by an adequate supply of cooling air, which is forced by a blower through a flexible hose

system to the drives for the table and carriage. The reinforced hose at *H* in Fig. 4 is connected to the delivery side of the blower unit seen at *J* in this illustration, and is led through the saddle cover. From this point, two secondary pipes distribute the air to the drives for the saddle and table. A 1/16-h.p. motor drives the impeller of the blower unit. The flexible conduits of smaller diameter, seen in the illustration, contain the cables which lead from the console to the servo-motors and Inductosyns.

In Fig. 5 is shown a view of the head of the machine, with the protective covers removed so that the arrangement of the spindle and controls may be observed. Two Kopp Variators, of 1 h.p. and ¼ h.p. capacity, are mounted to the left and right, respectively, of the centrally-disposed spindle. The 1-h.p. Variator drives the spindle through a flat belt and pulleys, at speeds which are steplessly variable from 480 to 4,320 r.p.m. Feed rates from 6 to 54 in. per min. are provided by the smaller Kopp unit, through a reduction gearbox. A magnetic clutch in the drive enables the feed movement to be started from the console. The quill, mounted in Thomson ball bushes, is driven through a rack and pinion as may be seen in Fig. 6. In this illustration also may be seen the housing *K* for the spring whereby the quill is returned to the upper position, after a drilling operation has been completed. Travel of the spindle is controlled by upper and lower limit switches, which are set by the operator to suit the work. The control

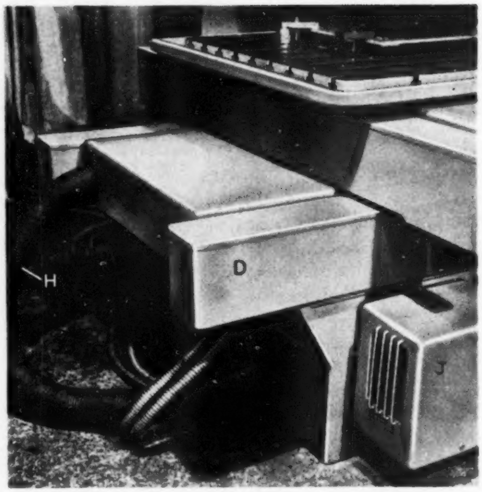


Fig. 4. View of One End of the Carriage and Table of the Co-ordinate Drilling Machine, Showing the Covers that Protect the Guideways

system comes into operation when the upper limit switch is closed, and the work table is moved automatically to the programmed position. At the conclusion of the drilling operation, the lower limit switch is tripped, and the spindle is withdrawn by the spring. The spindle, which is carried in six angular contact bearings, has a drilling capacity of ¾ in. and a traverse of 10 in. The chain seen at *L* in Fig. 6 is connected to a control dial on the front of the bridge and provides for adjusting the feed rate.

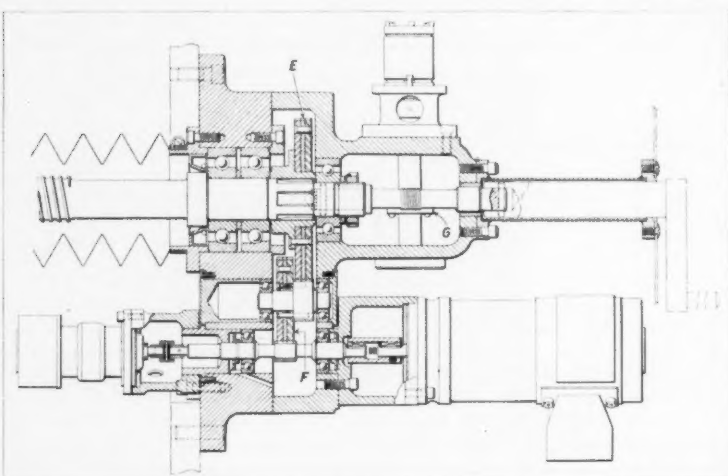


Fig. 3. Arrangement of the Gearbox which Incorporates Gears of Sandwich Construction, with a Nylon Lamination between Bronze Outer Plates, to Eliminate Backlash

EKCO CONTROL SYSTEM

The Ekco system of machine-tool control, mentioned in the opening paragraph of this article, is to be fitted to a co-ordinate drilling table. This co-ordinate table is being constructed by Industrial Technics for Buck & Hickman, Ltd., and is to

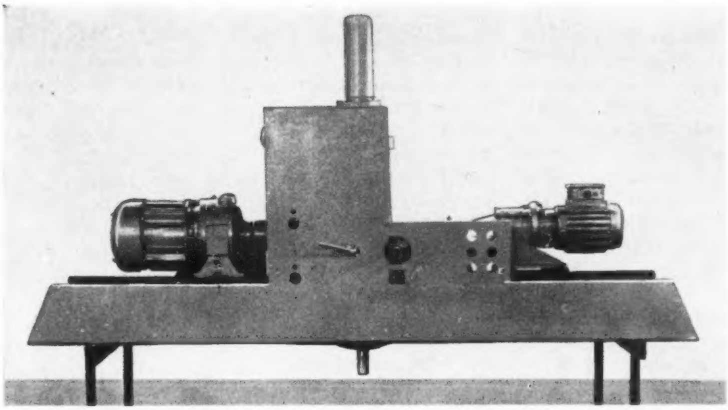


Fig. 5. A General View of the Head of the Machine, from the Front. The Drilling Quill Moves in Thomson Ball Bushes

be used in conjunction with a radial drilling machine. With this system of table positioning, a leadscrew serves as the measuring component.

Basically, the Ekco equipment comprises a control unit, seen in Fig. 7, which is coupled electrically to two traverse units. These latter units are fitted to the leadscrews of a compound work table, after the handwheels have been removed. Each traverse unit, as seen in Fig. 8, measures 9½ in. by 9½ in. by 4½ in. high, and consists of a drive mechanism, and a servo head which are coupled to the leadscrew through gears. The leadscrew is rotated through the required number of turns, as determined by the control unit, and the effects of backlash are avoided by uni-directional approach. It is stated that the traverse unit will position a 10 t.p.i. leadscrew to within $\pm \frac{1}{500}$ part of a single turn, over a traverse movement of 100 in. With a perfect screw, this performance represents 0·0002 in. of linear movement of the table. A ¾-h.p. series motor in the drive mechanism provides for rapid traverse at a speed of 24 in. per min., to within 0·1 in. of the required setting, and a low traverse rate is engaged for the final approach movement. The minimum continuous torque when driving a 4-t.p.i. screw is 115

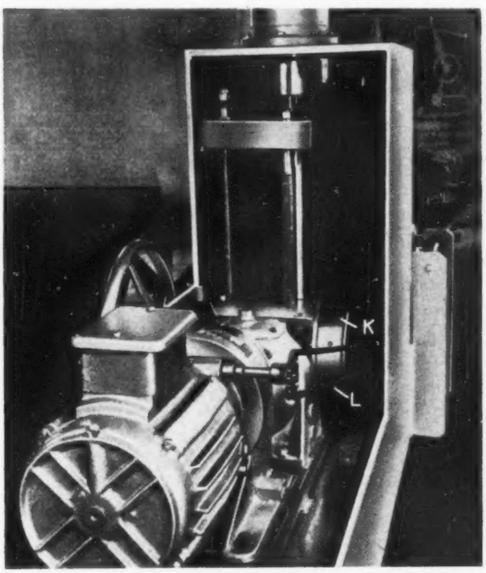


Fig. 6. In this View of the Head with the Covers Removed, the Rack for Traversing the Quill Downwards, and the Drive, which Incorporates a Kopp Variator, can be Seen

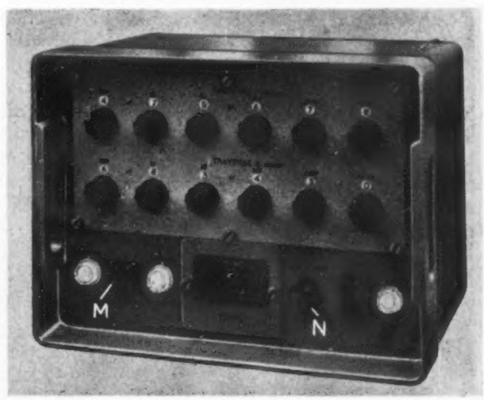


Fig. 7. This Ekco Control Unit is Part of the Alternative Positioning System which Can be Fitted to the Industrial Technics Co-ordinate Drilling Machine

lb.-in., but starting torques are considerably greater.

It will be appreciated that the accuracy quoted is re-set accuracy, and every workpiece will be produced to the same tolerance. Inaccuracies in couplings and leadscrew affect the absolute position of the table. If the leadscrew has cyclic or progressive errors, a calibration check can be made, and it is possible to apply corrections either mechanically or electrically. Uneven wear in service might give rise to errors, but such faults can normally be avoided by ensuring that the screw fitted is of a high grade, is well maintained, and is not subjected to heavy loads.

Push-buttons on the front of the traverse-unit housing, allow the operator to move the table in forward or reverse directions, at full speed or by " inching." By means of an indicator in the servo head, it is possible to check whether the leadscrew has actually made a number of turns corresponding to the setting of the control unit.

The control unit is contained in a metal housing measuring 15½ in. by 12 in. by 12 in. deep. Decade dials, arranged in two rows, are used for setting up the digits of the two co-ordinates, and knobs are rotated until the figures for a particular setting appear on the illuminated dials. Six dials are provided for each of the two traversing motions. The indicator lamps on either side of the start button indicated at *M* in Fig. 7, show that the clamps for both moving members have been applied. An auto/manual/zero switch *N* is used in conjunction with the push-buttons fitted on the traverse units already described. With the switch in the zero position, a datum can be established, at any point in the table movement, by setting the table where required and moving the servo-head indicator-dials to zero by the motor. The control system incorporates no valves, and consists of a

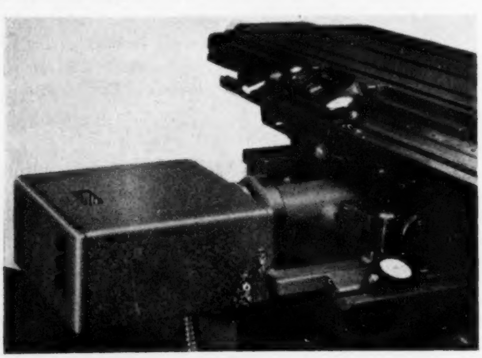


Fig. 8. One of the Traversing Units for the Ekco Control System, which, it May be Noted, does not Make Use of Valves

series of Wheatstone bridges, the master potentiometers of which are set to the desired measurement. During the table movements, slave potentiometers in each traverse unit are adjusted until the voltages in the bridges are balanced out. The first three digits of a co-ordinate are balanced, in sequence, by counters, coupled to the slave potentiometers, which count the number of turns made by the leadscrew. For resolution of the last three digits, there is a slave potentiometer with two wipers.

The first three decades control the ¾-h.p. motor, which provides the rapid traversing motion, to within 0·1 in. of the required setting. A small motor, controlled by the last three decades, runs continuously until the table is within 0·002 in. of the selected position, and the final movement is obtained by a series of short impulses which "tap" the table into position. Checking circuits are built into the equipment to facilitate the rapid location of faults and to simplify calibration. Components have been standardized where possible, and plug-in type sub-units can be changed rapidly if faults should develop.

When this system of machine-tool control is used, all dimensions for hole centres on drawings should preferably be related to a datum point. A planning sheet indicating the sequence of operations should also be provided, to ensure that the time taken to position the table is kept to a minimum. Fresh measurements can be set-up on the decade dials while machining is in progress, since the traverse units will not come into operation until the " start " button is pressed.

Development work is in progress which will enable a punched-card, information-storage system to be used in conjunction with the existing Ekco traverse units. It is anticipated that information for drilling a maximum of 23 holes will be contained on one card, and control signals for sequential operation of the machine-tool will be provided.

FACE MILLING WITH A CARBIDE CUTTER. It is reported by Protolite, Ltd., Central House, Upper Woburn Place, London, W.C.1, that a 6-in. diameter Futurmill, with 12 blades of Prolite grade MX.202 carbide, is being used with good results to machine the joint faces of heavy-duty gearboxes. These components are steel castings, certain portions of which have previously been welded, so that the milling conditions are rendered more severe by sand inclusions and hard spots.

Previously, the castings were milled at a speed of 75 ft. per min. with a feed of 2 in. per min. With the Futurmill, an ⅛-in. deep roughing cut is taken at 300 ft. per min. with a feed of 19·8 in. per min., and a finishing cut at 600 ft. per min.

Whaley Profile Milling Machine for Wing Models

A special profile milling machine has recently been installed by the Lockheed Aircraft Corporation, U.S.A., to facilitate the production of wings for wind-tunnel models employed in the research and design studies associated with new ultrasonic aircraft. This machine is one of four that have been built by the Whaley Engineering Corporation, Norfolk, Va., U.S.A., the other three units being installed in the laboratories of the National Advisory Committee for Aeronautics, where the profile milling machine was originally designed and developed.

Model wings can be produced from a variety of materials, including high-strength steels and duralumin. Lift surfaces of models can be milled within 0·003 in. of the design dimensions, and it is stated that the use of the machine has enabled the cost of producing model wings to be reduced by nearly 40 per cent.

The Whaley machine is shown in Fig. 1, and its base member takes the form of a 12- by 4-ft. surface plate, which is mounted on a conventional surface-plate supporting structure, and thus forms a rigid bed. At either end of this bed there are dovetail slideways, whereon carriages can be traversed by means of screws and nuts, operated by handwheels. Each carriage supports a stout cylindrical column, on which a sleeve member can be moved up and down by means of another hand-operated screw. Both the sleeves and their associated carriages can be locked in any desired position by manually-actuated clamps. Each sleeve carries a horizontal bearing, the axis of which is parallel with the major axis of the table. A shaft passes through the bearing, and to its outer end is secured a heavy-section lever carrying counterweights.

The shaft at one end of the machine—farthest from the camera in Fig. 1—is slotted, and through the slot passes a large-diameter horizontal pin. Each end of the pin is secured in one arm of a yoke piece, which supports one extremity of a massive beam. The mounting arrangements for the other end of the beam are shown in the perspective view, Fig. 2.

A braced cantilever bracket *A* is fixed to the beam, and a fork piece *B* is pivoted to it. The arms of this fork are pivoted to the arms of a second fork *C*, which is attached to a horizontal shaft *D*, and the latter is free to rotate in a bearing on the vertically-sliding sleeve at that end of the machine. The axes of the shaft, the pivot pin connecting the bracket *A* and the fork *B*, and the pins connecting the forks *B* and *C*, intersect at the point *X*. Mounting arrangements for the beam are such that the complete assembly can be swung about the horizontal shafts, through 15 deg. on either side of the vertical plane, and this movement is facilitated by the provision of a quadrant, secured to the fork *C*, which meshes with a worm on the vertically sliding sleeve. This worm is rotated by means of a handwheel.

By moving the carriages, on which the columns are mounted, along their guideways, the beam can be set at angles up to 30 deg., in either direction, relative to the longitudinal axis

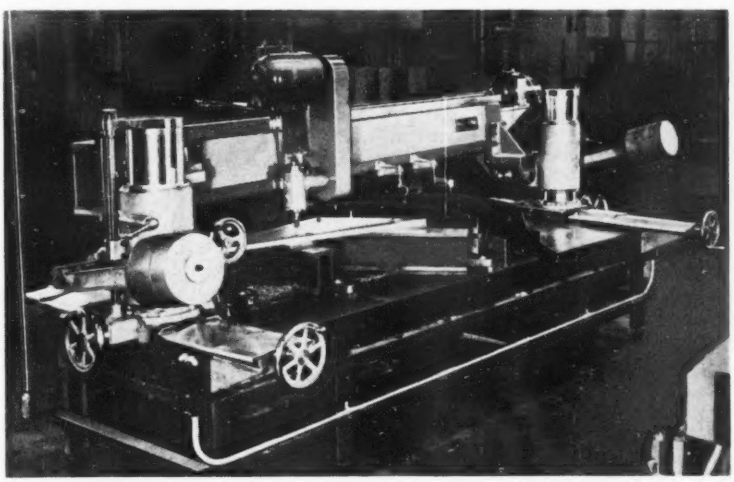


Fig. 1. A General View of the Whaley Milling Profile Machine for Generating Model Wings

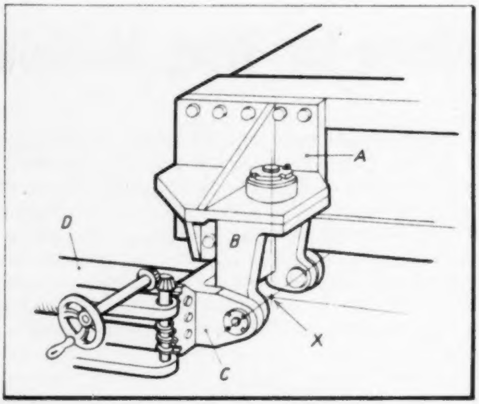


Fig. 2. Details of the Mounting Arrangements for One End of the Beam which Carries the Cutter Head are here Shown Diagramatically

of the surface plate. At the same time, by adjusting the heights of the beam supports on each vertical column, the beam can be tilted lengthwise relative to the top of the surface plate.

A cutter head can be moved along on slideways on the beam, by means of a feed screw driven by a ¾-h.p. variable speed unit. Steplessly-variable rates of feed are obtainable, from 0 to 65 in. per min. The cutter head incorporates a vertical spindle, which is driven by chain from a 1-h.p. geared motor unit. A 155-r.p.m. motor unit is employed for cutting steel, and cutter speeds from 41 to 261 r.p.m. are available. For cutting duralumin, a 1,800-r.p.m. motor unit is employed, and the cutter speeds then range from 720 to 2,000 r.p.m.

The Whaley machine can be used for operations on trapezoidal or delta wing models. For trapezoidal models, two templates are employed to set the beam, one template governing the profile at the small end of the wing shape, and the other the profile at the large end. Profiling operations are carried out with an end-mill type cutter, which is applied in a series of longitudinal (spanwise) traverses from one end of the workpiece to the other. Before each traverse is made, the beam is set to the templates, mounted on the table, with the aid of two sensitive dial indicator gauges, carried on brackets attached to the beam, and the cutter, therefore, is presented so that it is tangential to the wing surface that is to be machined.

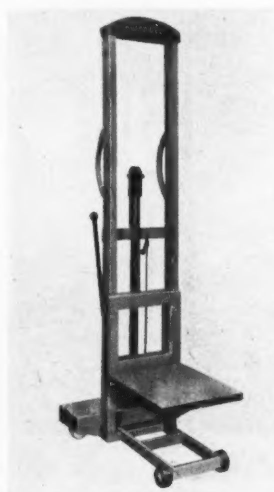
For delta wing models, only one template is employed, and this template corresponds to the profile at the large end. The workpiece is set so that the apex of the wing is located at the intersection point *X*, Fig. 2, and a true delta form is therefore generated.

Trapezoidal wing models up to 98¼ in. long, and measuring 42 and 48¾ in. at the small and large ends respectively, can be machined. Delta wing models up to 96 15/16 in. long, and measuring 42½ in. wide at the large end, can be machined, when using the standard long beam. A shorter beam is also available, and one end can be set at three different lengthwise positions on the table. With this beam, delta wing forms measuring 52 15/16 in. long by 38⅛ in. wide, 44 3/16 in. long by 36 9/16 in. wide, and 28 3/16 in. long by 32½ wide, can be handled. Although the machine described is arranged for hand control, automatic control systems can be incorporated.

Powell Vertolifter Hand-operated Platform Truck

Powell & Co., Burry Port, Carms., South Wales, are the makers of the Vertolifter platform truck, here shown, which will raise loads up to 500 lb. to a maximum height of 55 in.

Available in widths of 9½ and 15½ in., the 19-in. long platform is moved vertically in the steel channel-section frame on four roller-bearing mounted guide wheels, by means of a hydraulic cylinder and roller chain, the oil supply to the cylinder being provided by a hydraulic pump. The truck, which is 23½ in. wide, has swivel casters at the rear end to enable it to be turned in its own length.



Powell Vertolifter Hand-operated Platform Truck Which will Raise a Load of 500 lb. to a Height of 55 in.

Machine Shop Patents

AN AIR-OPERATED WRENCH

The accompanying drawing shows a sectional view of an air-operated ratchet wrench. An air motor, with its associated throttle lever, forms the handle of the wrench. The face cam *A* is keyed to the air motor shaft, and, as this cam rotates, it serves to impart a reciprocating motion to the plunger *B*.

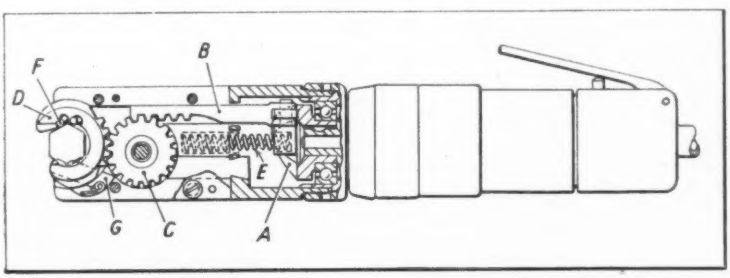
Rack teeth on the left-hand end of the plunger *B* mesh with an idler gear *C*, which, in turn, engages with teeth cut on the periphery of the wrench head *D*. Reciprocating motion of the plunger *B* is thus converted into rotary motion of the wrench head *D*. The plunger *B* has a free-running roller at its right hand end, and is maintained in contact with the cam *A* by means of the spring *E*.

In the wrench head *D* there are two rollers *F*, which are biased into seatings at the left by springs, but can move to the right, against the spring pressure. The rollers *F* make contact with the adjacent flat faces on a hexagon nut, and, when the head *D* is rotated in a clockwise direction, impart a similar motion to the nut. When the head *D* is rotated in an anti-clockwise direction, the rollers *F* ratchet across the corners of the nut.

The blade *G*, pivoted in the body of the wrench, passes through a slot in the head *D*, and is spring loaded so that its outer end tends to move in a clockwise direction. When the wrench is applied to a nut or bolt in the axial direction, the blade *G* acts as a stop, and prevents the wrench from passing beyond the head portion. Alternatively, when the wrench is applied to the nut from the side, a notch in the blade *G* engages the corner opposite to that spanned by the rollers *F*, and thus prevents the nut from turning when the head *D* is rotating in an anti-clockwise direction.

For loosening nuts the wrench is inverted.

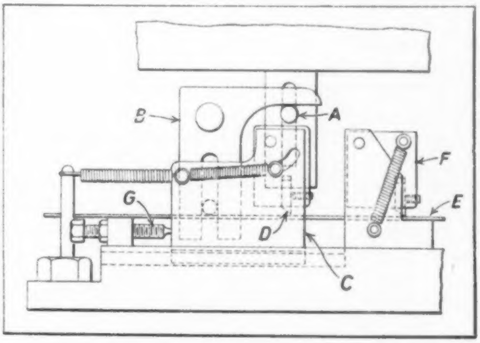
786,227. The Aro Equipment Corporation, Ohio, U.S.A. [*Application date August* 15, 1955. *Published November* 13, 1957.]



Sectional View of an Air-operated Wrench

AN INTERMITTENT-FEED MECHANISM FOR STRIP MATERIAL

A mechanism for intermittently feeding strip material to length is shown in the accompanying drawing. The mechanism is actuated by the pin *A*, which is attached to a slotted plate fixed to the underside of the vertically-reciprocating member of a press, or similar machine. As the pin *A* moves in the vertical plane it pivots the bell-crank *B*,



Intermittent-feed Mechanism for Strip Material

which has an open-ended slot in its lower end engaging with a pin projecting from one side of the sliding block *C*. The block *C* is guided, and can move in the horizontal plane only, so that vertical movements of the pin *A* produce horizontal reciprocation of the block. Housed within the block *C* is

a pivoted holder and blade *D*, the latter being held in contact with the strip material *E* by means of a tension spring.

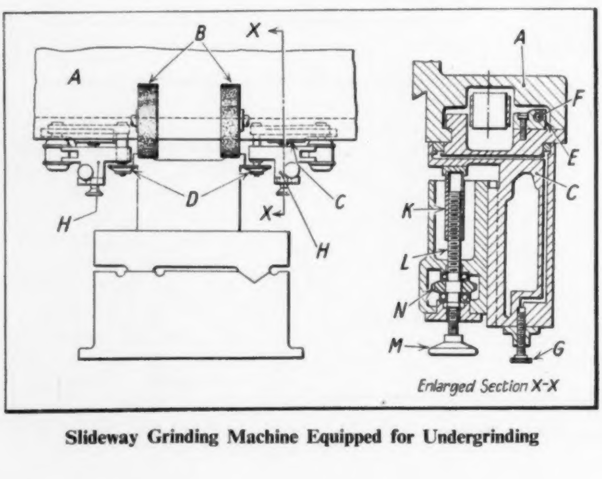
As the pin *A* moves vertically upwards, the block *C* moves to the right, and, through the gripping action of the blade *D*, the strip material is fed in the same direction. A second spring-loaded and pivoted blade-holder *F* prevents the strip material from moving back when the block *C* is returned by its associated tension spring, seen at the left. The adjustable screw *G* limits the return movement of the block *C*. and the extent of the forward stroke of the latter is determined by the position of the pin *A* in its slotted plate.

785,315. William Rhodes, Ltd., Carlton Cross Mills, Leeds, and Joseph Cemm, Rhodosteel Works, Leeds. [*Application date, December* 28, 1954. *Published October* 23, 1957.]

SLIDEWAY GRINDING MACHINE EQUIPPED FOR UNDERGRINDING

The accompanying drawing shows a grinding machine for finishing the upper and lower guideways of a machine bed, simultaneously.

A base supports the reciprocating table to which the workpiece is secured. The table passes beneath the cross-beam *A*, which has guideways on the front vertical face for heads carrying the grinding wheels B. Additional guideways, on the lower horizontal face of the beam, support the carriages *C* for the grinding wheels *D*. The carriages *C* can be traversed horizontally along the cross-beam *A*, by means of the nut *E* and the screw *F*, in section X-X, and they can be clamped, hydraulically, by turning the hand-wheel *G*.



Slideway Grinding Machine Equipped for Undergrinding

There are vertical slideways on the carriages *C* for the grinding-heads *H*, and each head can be traversed vertically by means of a threaded sleeve *K* and a screw *L*. A coarse adjustment can be obtained by turning the hand-wheel *M*, and a worm and wheel *N* is provided for fine adjustment. The worm and wheel *N* can be separated by means of an eccentrically mounted sleeve, not shown.

An inner extension on the grinding heads *H* houses a grinding spindle and vertically adjustable quill, and an outer extension carries an electric motor, mounted with the shaft vertical. The drive is transmitted from the motor shaft to the grinding spindle by a flat belt, which runs in a clearance space in the under-side of the cross-beam.

784,753. Gesselschaft der Ludw. Von Roll'schen, Eisenwerke A.G., Gerlafingen, Switzerland. [*Application date, in Switzerland, March* 20, 1954. *Published, October* 16, 1957.]

New Mullard Photo-electric Cell.—Mullard, Ltd., Mullard House, Torrington Place, London, W.C.1, have recently developed a new type of photo-electric cell, for which an exceptionally high degree of sensitivity is claimed. It incorporates a cadmium-sulphide photo-sensitive element, the electrical resistance of which is reduced by an interdigital pattern of copper strips.

With the new cell, it is claimed, using low applied voltage, sufficient current can be produced, with a weak light scource, to operate a large capacity relay without the need for an amplifier. Suitable for use in conjunction with most arrangements for on-off switching operations at speeds up to about 50 cycles per sec., the new cell is expected to find numerous applications in connection with lighting control, industrial counting processes, smoke monitoring, and warning systems and safety control devices, for example. Since maximum response is obtained from the yellow/red portion of the spectrum, it is particularly suitable for flame-failure detectors for oil-fired boilers.

Quantity production of a comprehensive range of cadmium-sulphide photo-electric cells will shortly be started by the company. The range will include cells of various types with different electrical ratings, and photo-cathodes with areas from a few square millimetres to several square centimetres. They will have valve bases similar to those of conventional Mullard photo-electric cells, production of which will continue.

New Production Equipment

Harbots 618 Precision Hydraulic Surface Grinding Machine

Harbots, Ltd., Devonshire Road, Leicester, have recently developed the 618 precision hydraulic surface grinding machine, shown in the figure, for operations on slip gauges and similar parts, and for general production work where a high degree of surface finish is required. The working surface of the table is 18 by 6 in.

Easily detachable and interchangeable, the wheel-head is designed to run at "just warm" temperature. It has long, precision-ground, V-slide surfaces which move on hardened and ground slideways, and is balanced and fully enclosed in the column, which affords protection from dust. The maximum vertical traverse is 11 in., and there is a positive fine feed adjustment of 0·0001 in.

Made from Nitralloy steel, the spindle is heat-treated and ground all over, and runs in adjustable plain taper and thrust bearings. Drive is taken through a flat, endless belt, with a tension-adjusting device, from a 1-h.p. precision-balanced motor, which is mounted on the column and housed in the base of the machine.

The grinding wheel, of 7 in. diameter by ½ in. face and 1¼ in. bore, runs at 2,650 r.p.m., and is carried on an adapter which can readily be removed for balancing or wheel changing. With this arrangement, wheels can be stored for further use in the trued and balanced condition.

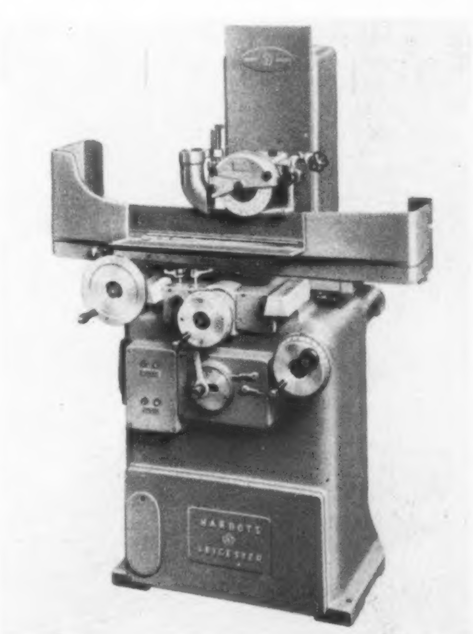
For the hydraulic system, a pump unit, with self-contained ½-h.p. motor and oil tank, is housed in the base of the machine, and isolated by rubber mountings. The working pressure is 130 lb. per sq. in., and the unit is situated behind the front cover, to facilitate inspection.

Longitudinal table traverse up to 19 in. can be obtained in either direction, either by handwheel or hydraulically, and the power movement can be steplessly varied from 0 to 45 ft. per min. Provision is made for smooth reversal, and the flat and vee table ways are pressure-lubricated with filtered oil by a separate supply from the hydraulic system.

Both hand and hydraulic cross-traverses, up to 6¾ in., are available for the table in either direction. The handwheel is graduated in increments of 0·001 in., and the hydraulic cross-feeds range from 0·002 to 0·045 in. at each reversal. There is an automatic trip mechanism for the transverse movement.

For dry grinding, a dust collecting unit with facilities for easy cleaning, can be provided, and the wet grinding equipment includes an electric pump. Both wet and dry grinding equipment can be fitted and used alternatively.

The floor space occupied by the machine is 67 by 38 in., and the approximate weight, 17 cwt.



Harbots 618 Precision Hydraulic Surface Grinding Machine

Pégard A.F.9 Horizontal Boring Machine

The type A.F.9 horizontal boring machine shown in the figure has recently been added to the range built by Ateliers Marcel Pégard S.A., Andenne, Belgium, for whom the sole agents in this country are George Cohen Sons & Co., Ltd., Machine Tool Division, Sunbeam Road, London, N.W.10.

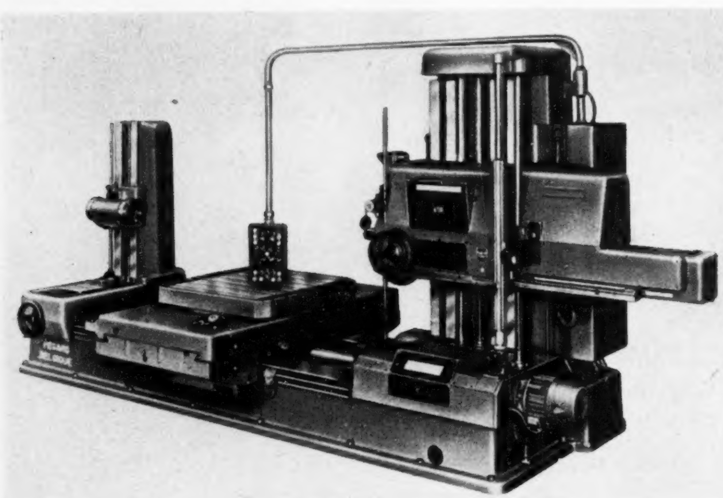
This machine is available with a 3½- or 4-in. diameter spindle, and the carriage for the T-slotted rotary work table can be traversed on the bedways for a maximum distance of 51 in., when the boring stay is mounted on the end of the bed as shown. Alternatively, a longer bed is available, which enables a maximum table travel of 78·6 in. to be obtained. A cross-slide movement of 39·4 or 63 in. can be provided. The spindle head can be traversed vertically for a maximum distance of 39·4 or 51 in., according to the height of the column, and a maximum distance of 41½ or 53½ in. is obtainable between the spindle axis and the working surface of the table.

Eighteen speeds, which may range from 18 to 900 or from 28 to 1,400 r.p.m., are provided for the boring spindle, the drive being taken from a 15-h.p. motor. Bored to take a No. 5 Morse taper shank, the spindle has an axial travel of 31½ in., and 12 feeds ranging from 0·0005 to 0·025 in. per rev. are available. If required, a gear box can be provided which enables 23 Whitworth or metric screw threads to be cut. An adjustable stop is fitted for controlling the spindle travel, to facilitate boring holes to predetermined depths.

A 26-in. diameter facing head, or an 8$\frac{21}{32}$-in. diameter milling nose, to take large-diameter cutters, may be mounted on the main spindle, which has 18 speeds, ranging from either 4½ to 224 or from 7·1 to 355 r.p.m. With the facing slide, surfacing cuts can be taken on diameters up to 47 in., and there are 12 radial feed rates for the cutter slide, from 0·002 to 1 in. per rev. Both the main and boring spindles run in heavy-duty anti-friction bearings.

Twelve feeds, which also range from 0·0005 to 0·025 in. per rev. of the boring spindle or from 0·002 to 1 in. per rev. of the facing slide, can be applied to the table and spindle head. For heavy-duty milling operations, drive to the feed gear box is taken from a separate 5-h.p. flange-mounted motor, and the 12 table and spindle head feeds then obtainable range from ¾ to 39 in. per min. Spindle speeds and cutting feeds can be preselected, while the machine is in operation, by means of knobs, and are brought into use pneumatically, as required, by pressing push-buttons. Cutting speeds and feeds are indicated on illuminated panels on the spindle head and feed gear box.

Rapid power traverses at the rate of 110 in. per min. are provided, and, for accurate setting, the spindle head and table can be adjusted by hand, or under power at the rate of 0·15 in. per min. Provision is also made for inching the boring spindle and facing head. Twelve speeds ranging from 0·022 to 1 r.p.m. are provided for the rotary table. In addition the table can be rotated at speeds of 2·8 r.p.m. for rapid adjustment, and 0·0035 r.p.m. for final setting. Optical measuring equipment is incorporated, which gives readings to 0·0005 in. for adjustment of the table transversely and the spindle head vertically, and to 6 sec. of arc for setting the table for angle. Provision can be made for automatic co-ordinate setting of the spindle head and table, by means of stops adjustably-mounted on 8-position indexing bars. The spindle head and table are then rapidly



Pégard Type A.F.9 Horizontal Boring Machine

traversed for approximate adjustment, and the low-speed power movements are automatically engaged for the final settings. It is stated that in this way settings can be made to an accuracy of 0·0004 in.

When a setting has been obtained, air-operated clamps are automatically brought into use for securing the spindle head, rotary table, cross slide and saddle to their guideways. A pressure-operated relay is incorporated in the clamping system for stopping the machine in the event of failure of the compressed air supply. Lubrication of the column, bed and table ways is effected by an air-operated force-feed system. All motions of the machine are controlled by push buttons and switches mounted on a pendant-type unit.

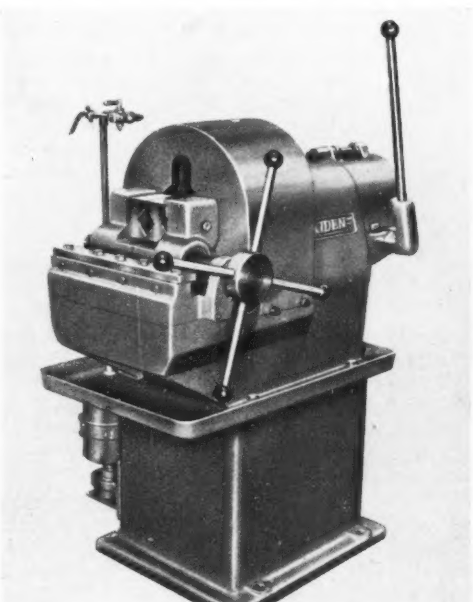
Maiden 4-in. Capacity Bar and Tube Chamfering Machine

Maiden & Co., Ltd., Hyde, Cheshire, have recently increased their range of bar chamfering machines by the addition of the 4-in. size, here shown. Primarily intended for chamfering bar stock which will be used on automatics, these machines can also be employed for preparing tube-ends for welding. The work is held in a self-centring manually-operated vice, and a steady for supporting the outboard end of the bar is supplied as part of the standard equipment. A 3-h.p. motor drives the single-speed cutter spindle, which is fitted with four tools, and two sets of tools suffice for the full range of bar diameters from 1 to 4 in.

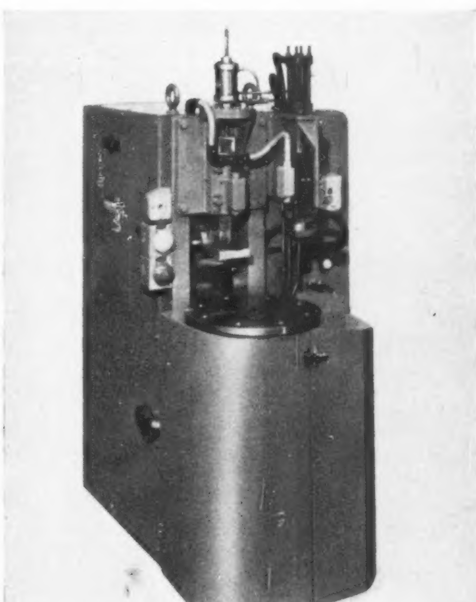
The cutter spindle is advanced manually, by the single lever seen at the rear of the machine, and automatically returns to its former position when the lever is released. A coolant sump is housed within the base casting, and a motorised pump and coolant delivery system are provided.

Sciaky PAGM 10 Indexing Table Welding and Hot-riveting Machine

Sciaky Electric Welding Machines, Ltd., Falmouth Road, Slough, Bucks., have recently extended their range of indexing, spot-welding equipment by the addition of the machine here illustrated. Known as the PAGM 10, this machine, which has a rating of approximately 100 kVA., is suitable for spot or projection welding, or hot-riveting, and is intended for operations on fairly small components, such as electrical contacts, transistors, and similar electrical parts.



Maiden 4-in. Capacity Bar and Tube Chamfering Machine



Sciaky PAGM 10 Indexing Table Welding and Hot-riveting Machine

The worktable is indexed by an electric motor, and a gearbox provides a range of speeds up to 50 per min. An air-operated pressure head is employed for riveting, and a damper serves to absorb the shock. The riveting mechanism is interlocked with the table indexing arrangement, so that the table cannot be rotated when the pressure head is in the working position.

As the welding is usually of a rather delicate nature, an ignitron contactor, in conjunction with an electronic timer, is used to control the operation. The worktable is designed to receive welding and riveting jigs or fixtures, and loading is normally carried out by an unskilled operator. However, provision can be made for magazine loading, and then one operator can tend several machines.

Jones-Shipman Automatic Crush Form Grinding Machine

Recently introduced by A. A. Jones & Shipman, Ltd., Narborough Road South, Leicester, the crush form grinder shown in Fig. 1 has been developed from the type 1012 machine, and is designed for operation on an automatic cycle.

A close-up view of the drive arrangement for providing down feed and rapid return of the wheel-head is given in Fig. 2. Steplessly-variable speeds up to 80 ft. per min. are obtainable for the hydraulically-operated, 27-in. by 10-in. table, which has a maximum stroke of 29 in., and a hand cross-adjustment of 11¼ in. is provided for the saddle, for setting purposes. There is a lever for starting and stopping the table, and other motions of the machine are controlled by push buttons and switches, which are conveniently grouped on the front of the bed.

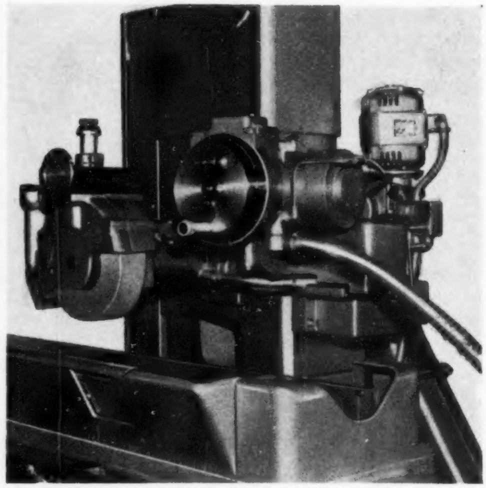


Fig. 2. Close-up View of the Drive Arrangement for Power Feed and Rapid Return of the Wheel-head

When a master rotary switch is turned to the position marked "on," the reciprocating motion of the table can be started by movement of the control lever. By setting a second rotary switch to a position marked "automatic," power down feed, through a maximum distance of 0·30 in., is applied to the wheel-head, at a rate which can be varied from 0·075 to 3 in. per min. When the lowest feed rate, and a table speed of 120 strokes per min. are employed, a cut of about 0·0006 in. is taken on the work at each pass. At the end of the pre-set downward movement of the wheel-head, a contact is opened, which causes the rapid return traverse to be automatically engaged. At the

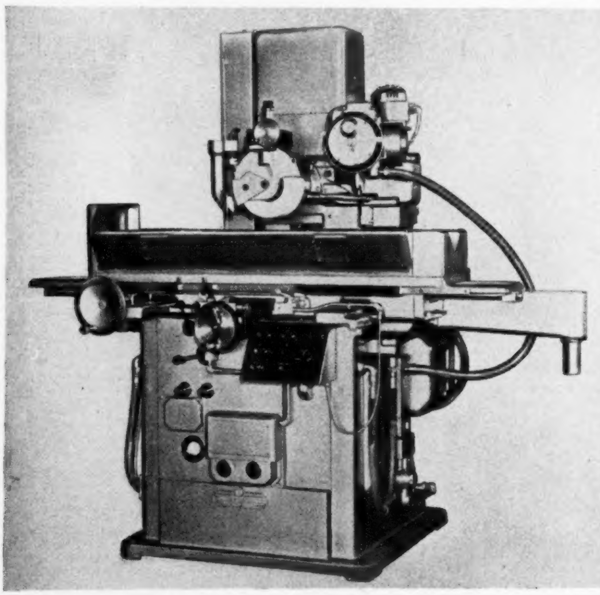


Fig. 1. Jones-Shipman Automatic Crush Form Grinding Machine

same time, the table is moved to its pre-set left-hand position.

The second rotary switch has two other positions, one of which enables the wheel-head to be held at the top of the power feed stroke while the table is reciprocated. When the switch is moved to the other position, for setting purposes, the wheel-head is brought down and then held at the bottom of the power feed stroke while the table is reciprocated. Movement of the table can be stopped either by the control lever or by a "return cycle" push button. Release of a clamping arrangement on the handwheel enables the drive mechanism for power feed to be disengaged, and the wheel-head can then be adjusted by hand for applying the cut to the work, and for setting, to suit the height of the piece to be ground. In addition, provision is made for fine vertical adjustment, by hand, to compensate for wheel wear.

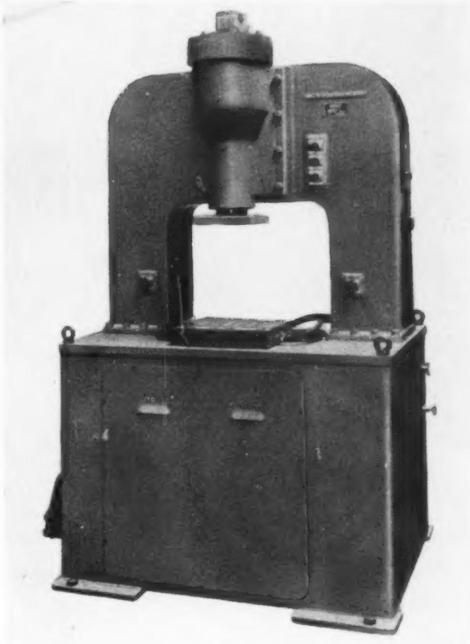
A maximum distance of 12 in. is obtainable between the periphery of a new 10-in. diameter grinding wheel and the top surface of the table. Wheels up to 1 in. wide may be mounted on the spindle nose, and special flanges can be provided, which enable recessed wheels with maximum face widths of 2 and 3 in. to be employed.

Drive is taken from a 3-h.p. motor, and spindle speeds of 2,040 and 2,700 r.p.m. are obtainable, which provide a peripheral speed of 5,300 ft. per min. with wheels of 10 and 7½ in. diameter. The hydraulic pump, also a pump for the lubrication system, are driven by separate motors. For crush-dressing, which is carried out by a motor-driven roll, the spindle is driven at a slow speed. The equipment includes a master reference roll unit and a built-in wheel-truing attachment.

Metrovick Series Projection Welder

The series projection welder shown in the accompanying illustration has been developed by the Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester 17, and is intended for the quantity production of welded components. Known as the model APS60/24, the machine is of bridge-type construction, with a gap of 24 in. between the uprights, and an 8½-in. diameter air-operated ram developing a thrust of 4,500 lb. The thyratron timers, for controlling the welding period, the ignition contactor, and the transformer, are contained within the machine base, and, whereas the transformer is rated at only 60/kVA, it is claimed that the performance of this machine is equivalent to that of a conventional machine of considerably higher rating.

A platen measuring 12 in. by 13 in. supports the



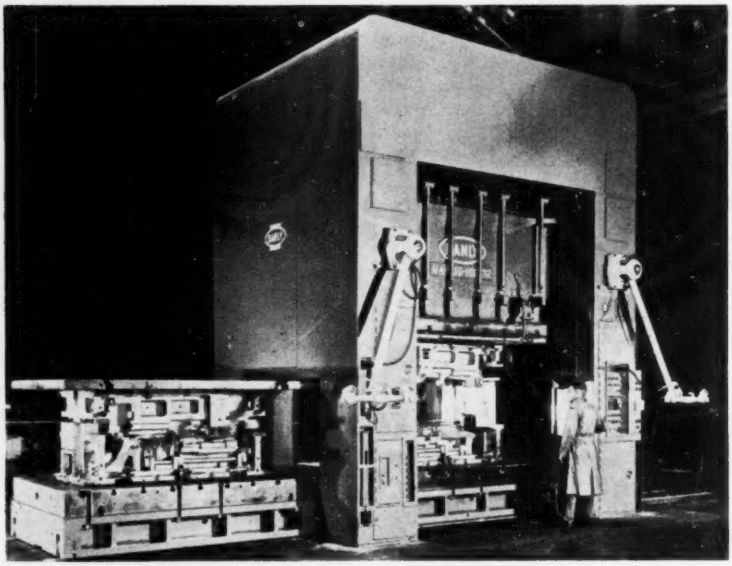
Metrovick Series Projection Welder

work, and a typical application of the machine is for welding 80 crossed wire joints, simultaneously. It has also been employed for simultaneously welding two bosses to a compressor shell.

Danly 500-Ton Quick Die Change Press

Built by Danly Machine Specialties, Inc., Chicago, Illinois, U.S.A. (whose products are now also being made in Great Britain), the single-action press shown in the figures has two bolsters secured to separate wheel-mounted carriages. These carriages are power traversed on guide rails at shop floor level, and pass through openings in the sides of the press frame. With this arrangement, other dies and tooling can be mounted and prepared on one bolster, whilst different parts are being produced on the other bolster.

When the set-up is to be changed, the upper die of the first tool is released from the press ram, so that it rests on the lower half, and both carriages, with the bolsters, are then moved on the guide rails in the same direction—either separately, or simultaneously—by depressing a push-button. As



Danly 500-ton Single-action, Quick Die Change Press

a result, the bolster carrying the first press tool is moved clear of the frame, and the second bolster is brought to the working position and located by means of a stop.

When the bolster is thus positioned in the press die area, the carriage wheels are supported by the rams of hydraulic cylinders. The carriage, with the bolster, is then moved downwards on to the press bed, where it is accurately located by keys. Finally, the upper die mounting plate is clamped automatically to the press ram. The motor-driven ram adjustment is used to position the ram automatically, in accordance with the preselected shut height of the press tool, to an accuracy within $\pm 0{\cdot}005$ in., with the aid of a pre-set dial. A separate drive system, for "micro-inching," which is independent of the flywheel, is also incorporated. This feature enables die try-out to be undertaken at a slow ram speed, under full tonnage.

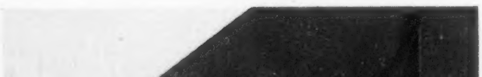
The system described can be provided for single, double, or triple action presses. A feature of the arrangement is that, since press tools are not moved towards the front or rear of the frame when the set-up is being changed, a number of presses can be installed fairly close to each other, and the need for disturbing the setting of any work-handling equipment provided between them is obviated.

Ability to mount and prepare different tooling on one bolster, whilst the press is in production on other parts, is a feature of particular importance when short production runs are to be undertaken.

Gaston E. Marbaix, Ltd., Devonshire House, Vicarage Crescent, London, S.W.11, are the selling agents in this country for Danly Machine Specialties, Inc.

PAS Unloading Unit for Presses

The overhead unit for unloading stampings from presses, here illustrated, has been introduced by Press Automation Systems, Inc., 25418 Ryan Road,



PAS Overhead Unit for Unloading Stampings from Power Presses

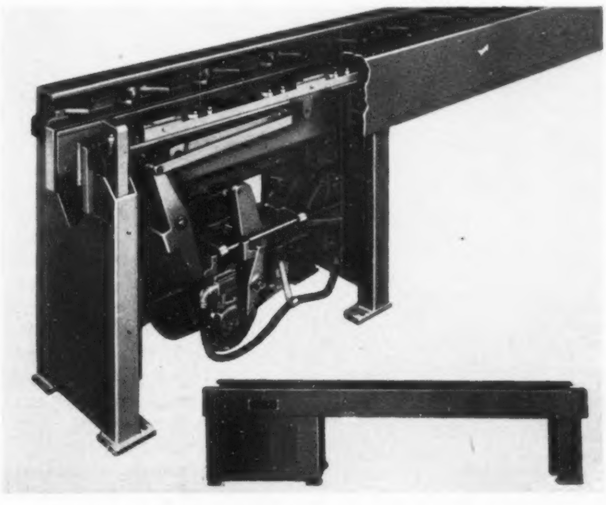
Centerline, Michigan, U.S.A. A bracket structure, which is secured to the crown of the press, carries a vertical slide arrangement which has a maximum movement of 42 in. A self-contained, hydraulic-powered, lifting system is provided, and vertical adjustment can be made from floor level. The unloader can thus be raised to clear the press working area when die setting is to be carried out. In addition, the standard PAS, air-powered, straight line unit, which is carried by the vertical slide, can be swung in the horizontal plane to a position parallel with the press crown, so that a crane may be used for die changing without interference.

As an alternative to the standard mechanical jaw assembly seen mounted on the straight line unit, a vertical lift or rubber vacuum cup type may be provided.

Dixon In-Line Transfer Table

Cut-away and side views of an in-line transfer table, introduced by Dixon Automatic Tool, Inc., Rockford, Ill., U.S.A., are shown in the accompanying figure. Workpieces, with a flat surface downwards, are slid along a track in the table top, and are clamped at successive stations by cams. It is stated that location within 0·005 in. can be obtained without the use of any auxiliary positioning arrangements, but by utilizing a lug or pin on the workpiece, more accurate positioning is possible.

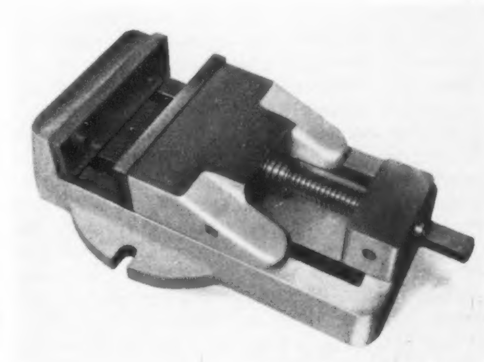
The indexing distance can be varied from 3 to 9 in., and the time required from 0·25 to 0·7 sec. These tables, which are normally made in lengths from 5 to 12 ft., can be employed where multiple, consecutive, operations are to be carried out, and parts can be handled at rates up to 6,400 per hour.



Cut-away and Side Views of the Dixon In-Line Transfer Table

Suprax Machine Vice

The Sigmax Engineering Co., Coronation Road, High Wycombe, Bucks., have recently placed on the market the Suprax machine vice, shown in the figure.



Suprax Machine Vice

The sliding jaw is guided for its entire length on the base, and a movement of slightly more than 6 in. is provided by a telescopic screw. The jaws have a width of 7 in., and are fitted with detachable, hardened steel plates.

The distributors for Suprax machine vices are A. Douglas & Co., Ltd., Lancaster Road, High Wycombe, Bucks.

DOMESTIC SEWING MACHINES produced in this country, for supply to the home market, reached a total of 34,400 during the third quarter of 1957. The totals for the first and second quarters of the same year were 29,000 and 36,700, respectively. For comparison, sewing machines produced during the last quarter of 1956 totalled 49,100.

Churchill-Redman Type P5 Automatic Multi-tool and Profile Turning Lathe

Churchill-Redman, Ltd., Halifax, have recently developed the type P5 automatic multi-tool and profile turning lathe shown in the accompanying Fig. 1. It has been designed to provide for maximum adaptability, and is built on the unit principle, to permit variations in construction so that specific components can be turned in the most economical manner. Both profile turning and multi-tool turning can be carried out simultaneously.

The basic machine comprises an overhead profile turning carriage mounted on a vertical bed, and a rear auxiliary in-feed slide. The tailstock is located on separate slideways at the front of the lower bed, and these ways are also used for mounting steady rests and work supports. With this arrangement, the spindle centre line is near the front of the machine at a convenient height, so that work loading and tool setting are facilitated.

Totally-enclosed slideways are provided on the vertical bed, which is mounted on a rigid base, and the latter also serves as a cutting oil sump. A feature of the lay-out is the provision for unrestricted chip clearance area, as indicated in the diagrammatic end view of the bed and tool slides in Fig. 2. It is thus ensured that chips do not build up in the work area, and, when required, an automatic chip conveyor can be provided to remove swarf from the rear of the machine. In addition, all the trip dogs, electric controls, template and tracer valve are located at eye level above the work area, where they are free from chips, dirt and cutting oil.

All the machine movements are hydraulically operated and electrically controlled from two easily accessible pendant panels. The electrical circuits are so designed that each movement can be separately controlled by push-button, to facilitate tool setting and change-over. There are no lever controls on the machine.

The complete machine cycle is automatic and the profile turning carriage, a close-up view of which is shown in Fig. 3, take a maximum of four successive cuts. During each cut, any form can be followed, within the tracing capacity of the machine, and parallel turning can be carried out when required. The machine sequence and the number of cycles are determined by setting rotary switches on the control panel. Hardened wearing strips are fitted to the profiling carriage, and it is traversed by means of a built-in hydraulic cylinder which provides steplessly-variable feeds.

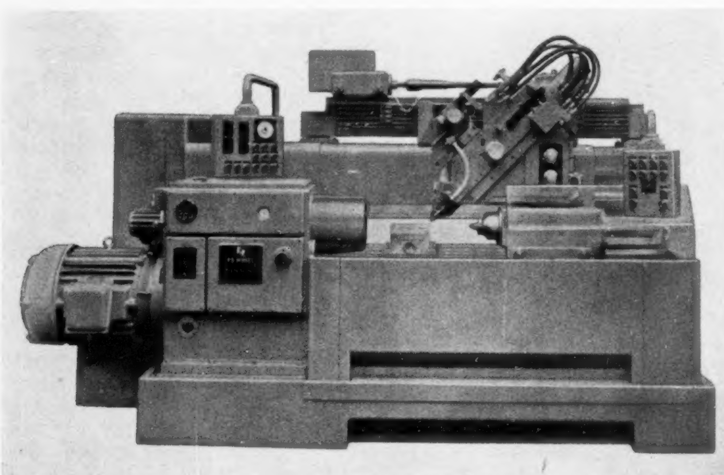


Fig. 1. Churchill-Redman P5 Type Automatic Multi-tool and Profile Turning Lathe

Carriage feed rate is determined by the setting of two hydraulic flow control valves, used either separately or in combination. If only one feed rate is required, it may range up to 60 in. per min. An automatic feed change is provided, however, so that two feed rates can be obtained during any cycle by setting trip dogs. The lower range maximum feed rate is then 30 in. per min., and the high range maximum

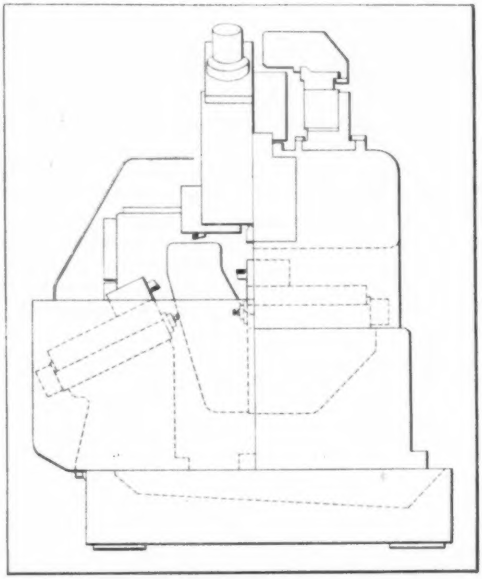


Fig. 2. End View of the Churchill-Redman P5 Lathe Showing Rear Slide and Front Bed

rate is 60 in. per min. There is also a rapid return speed of 20 ft. per min., and if required, the carriage can be arranged to give automatic skip feed.

Longitudinal travel of the profiling carriage is controlled by trip dogs. A separate manual adjustment of the angular tracing slide is provided for work diameter setting, which does not alter the lateral position of the tool relative to the template. Plate or circular templates may be used, and both can be adjusted in the horizontal and vertical directions. For multi-pass copy turning, the template is indexed automatically and a circular template with plate inserts is then employed. The tracer valve, designed and made by Churchill-Redman, has a carbide-tipped tracer finger.

Being designed for automatic production turning, the lathe is equipped with a simple and rigid headstock. A precision-balanced 30-h.p. motor is connected directly to the first motion shaft by a gear coupling, and drives the main spindle through hydraulically-operated self-adjusting clutches. Spindle speeds, from 250 to 2,000 r.p.m., or 125 to 1,000 r.p.m., are obtained by pick-off gears, and hardened helical gears are used exclusively in the transmission.

The spindle speed may be changed automatically in a 2 to 1 ratio during any or all of the four carriage cycles by means of electrical trips which operate the hydraulic clutches. Built into the main spindle is a hydraulic brake which operates automatically when machining has been completed. A tachometer is fitted, also a pressure gauge, which indicates the pressure in the headstock hydraulic system. This system, in addition to operating the clutches and brake, supplies lubricating oil to the headstock gears and bearings. If the supply fails, the spindle cannot be started. Also provided as standard, and mounted at the rear end of the spindle, is a hydraulically-operated chucking cylinder with pressure reducing equipment. If required, the chucking cylinder can be supplied hollow, for bar work.

The tailstock has a 5¼-in. diameter spindle with a built-in centre mounted in precision bearings. Operation is entirely automatic in sequence with the hydraulic chucking. Two automatically-operated hydraulic clamps are provided to secure the spindle in position during cutting. The tailstock, also, is provided with hydraulic pressure reducing equipment as standard.

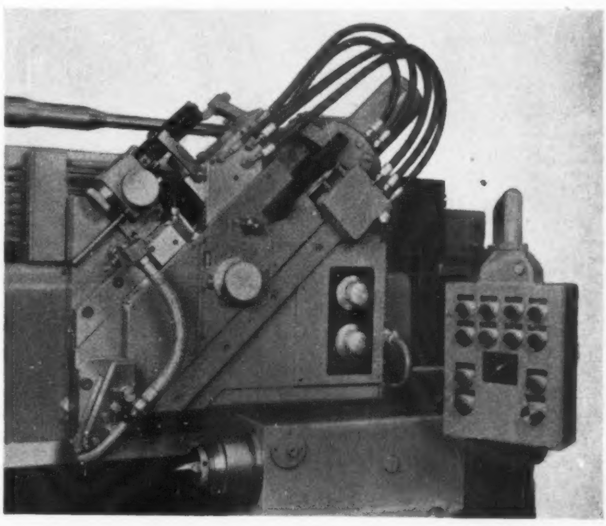


Fig. 3. Close-up View of the Profiling Saddle on the Churchill-Redman P5 Lathe. A Cylindrical Master is Seen in Position, but Flat Templates may be Used

On the standard machine, a heavy-duty auxiliary slide is rigidly mounted in a horizontal position in an opening in the vertical bed, so that it does not interfere with chip clearance. This rear slide is hydraulically operated and electrically controlled, and is arranged for rapid approach to the work, steplessly-variable feed, and rapid return. It is not necessary to alter any dogs or trips to re-set the slide for finishing a different diameter. At the end of the in-feed stroke, the slide contacts an adjustable dead stop, so that consistent work size is ensured. If required, the slide can be arranged to dwell at this point. The slide can be caused to operate automatically at any stage during the profile turning cycle, before that cycle has begun, or after it has been completed. Provision can be made for changing the spindle speed before the in-feed slide comes into operation.

As already indicated, the machine can be supplied in a variety of forms to meet customers' requirements. Thus, where necessary, the rear auxiliary slide can have a traverse motion for turning, or can be arranged to swivel to any angle. Alternatively, it may take the form of a multi-tool turning slide or an additional profile-turning slide. If additional cutting tools are required to machine the component in the most economical manner, the lathe can be supplied with a front bed. This bed can then be fitted with a front auxiliary slide, as indicated in Fig. 2, which may correspond to any of the rear slide variants mentioned above.

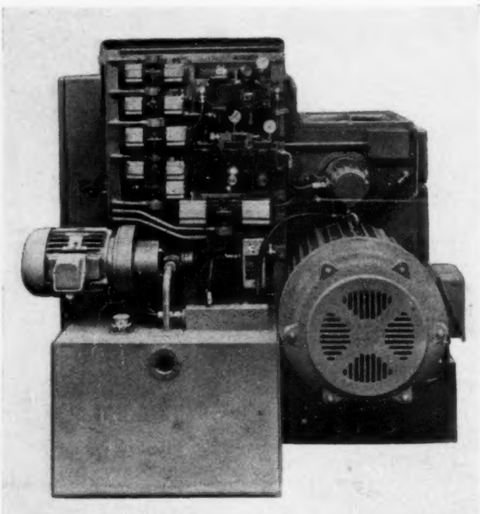


Fig. 4. End View Showing the Hydraulic Equipment and the Main Driving Motor on the Churchill-Redman P5 Lathe

Coolant is supplied by a motor-driven pump to the profiling slide and auxiliary slide tools, and the flow is automatically started and stopped with the machine cycle. Safety features are provided to guard against hydraulic pressure and mains supply failure. Electrical interlocks ensure that push-buttons cannot be operated incorrectly. For example, the "chuck and tailstock open" push-button is inoperative while the spindle is running, and the "machine cycle start" push-button is "dead" until the chuck and tailstock are closed.

The headstock, tailstock, slides and other working elements are lubricated entirely automatically and need no attention. Metered quantities of oil are fed to the required positions at specified intervals under the control of a timing switch.

All the electrical and hydraulic equipment used on the machine conforms to American J.I.C. standards. The hydraulic controls are panel mounted, as seen in Fig. 4, and the flange-mounting valves are easily interchangeable. All pipes and unions are of steel, and watertight electrical conduit is used throughout. The electrical equipment, as seen in Fig. 4, is housed on a separate panel mounted at the rear of the machine, and the control circuit operates on 110 volts supply. A separate tank, with a capacity of 35 gal., is provided for the hydraulic circuit oil. Unified screw threads are used throughout.

Automatic loading may be incorporated, when required, the hydraulic and electrical controls enabling such arrangements to be provided, with a minimum of complication. Loading may take place from a magazine, or the equipment may be of the automatic transfer type whereby the component is picked up from, and returned to, a conveyor. With the latter method, the conveyor can be used to link machines.

Additional equipment available for the machine includes a C-R 10-in. diameter 3-jaw hydraulically-operated, self-compensating chuck, a 12-in. diameter 3-jaw hydraulically-operated concentric chuck, steady rests, and profile boring equipment.

The machine illustrated swings a maximum diameter of 15 in., and admits 20 in. between the centres. The floor area required is 10 ft. 6 in. by 5 ft. 3 in., and the approximate weight is 6¼ tons. A similar machine to admit 40 in. between centres can also be supplied.

THE VALUE OF EXPORTS OF ALL TYPES OF MACHINERY (other than electric) from this country in January last was £48,077,251, as compared with £42,651,735 and £43,589,252 in January, 1957 and 1956, respectively.

Cromatrix Hard Chrome Plated Gauges

An important development by the Coventry Gauge & Tool Co., Ltd., Fletchamstead Highway, Coventry, is the introduction for their well-known Matrix plug and ring gauges, in both screw and plain types, of a hard chrome plating process, known as Cromatrix, which enables them to retain their original accuracy over extremely long periods of severe service.

Conventional hard chrome plating, to produce a wear-resistant surface on gauges and other parts, has, of course, been applied for many years, and the company has a large plant where this process, also other general plating work concerned with machine tools and gauging equipment, is carried out.

A disadvantage of the normal hard chrome plating process, however, is that where high precision is required for the finished part it is necessary to plate to an appreciable depth, and then carry out a finish grinding operation. This procedure, moreover, would not be practicable for ring and screw thread gauges. With the new Cromatrix process, which is claimed to represent an advance on other techniques at present employed in this country, the difficulties, particularly with regard to screw gauges, are overcome. The gauge is completely finished in the normal manner, prior to plating, except that it is made slightly undersize. Only a very thin coating of chromium, for example 0·0002 to 0·0003 in., is then applied, to produce a gauge within the prescribed tolerances, without the need for any subsequent finishing operation. The original surface finish is reproduced on the chrome coating, which is strongly adherent to the base metal, and is hard, homogeneous, and very uniform. Success of the process depends upon extremely close control of plating bath composition, temperature, current, and plating time, and the parts must first be thoroughly cleaned. With the conventional hard chrome plating process, whereby an appreciable thickness is deposited, the lower layers of the coating, exposed by the finish grinding operation, are usually about 25 per cent softer than the skin.

A view of one of the Cromatrix plating plants in the company's works is given in Fig. 1, and Fig. 2, shows the method of mounting 12 screw plug gauges in a holder for plating. The gauges are fitted with sleeves which mask the parts that are not to be plated, and they are lightly clamped endwise by means of screws.

During development of the Cromatrix process, sample gauges were sent to customers for trial under workshop conditions. In many cases, during the past year, a useful life ten times as long as would be expected from an ordinary gauge has been reported, and in several instances even longer life has been obtained.

Stocks of Cromatrix screw plug and ring gauges have now been built up by the company, and prompt delivery can be made of most standard sizes.

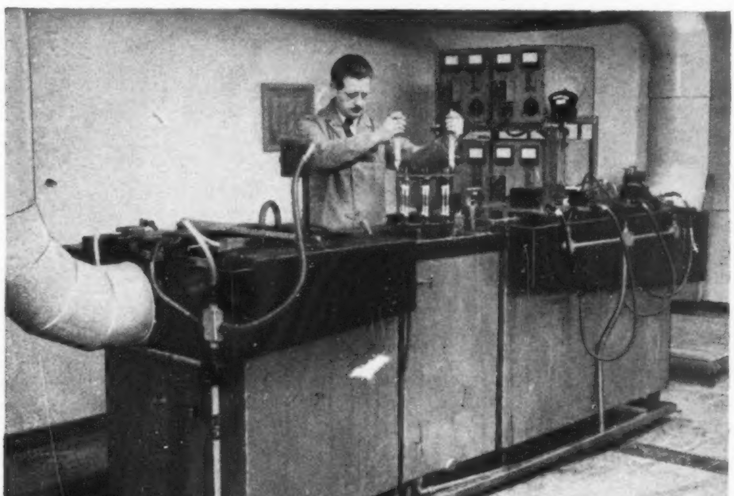


Fig. 1. One of the Cromatrix Hard Chrome Plating Plants Now in Operation at the Works of the Coventry Gauge & Tool Co., Ltd.

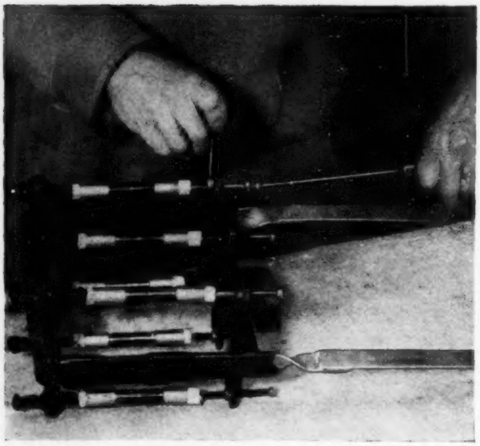


Fig. 2. Method of Mounting Screw Plug Gauges in a Holder for Cromatrix Plating

The cost of Cromatrix gauges is approximately 50 per cent greater than for untreated gauges. It is planned to extend the application of the process to cover the full range of Matrix gauges, including the anvils of plain and screw calipers, and high precision slip gauges. The largest vat at present installed has a plating capacity of 200 sq. in.

Whereas the company's interest as regards production applications is confined to gauges, the process has, of course, a much wider field. Development work is being carried out, for example, on the plating of cutting tools, including taps, drills, reamers, broaches, burnishers, and milling cutters, to ascertain the advantages to be gained. The plating of such components as master gears, worms and wormwheels, and high-speed spindles, it is believed, may also have important possibilities. The coefficient of friction of a Cromatrix plated surface is only about half that of hardened and ground steel. The company is therefore taking steps to make available technical information, also complete plating plants, to other firms who may wish to operate the Cromatrix hard chrome plating process under suitable agreements.

Carron Fabricating Department

Carron Co. inform us that owing to the increasing demand for sheet metal products and extensions to the range of work undertaken by their Press and Fabricating Department it became necessary to provide increased accommodation and additional and heavier equipment.

A new building with an area of 30,000 sq. ft. has therefore been erected at the main works at Falkirk, to which this department has now been transferred from the premises previously occupied in Washington Street, Glasgow. The heavy bay of the new building is equipped with an overhead crane of 10 tons capacity and the plant includes presses in sizes up to 100 tons.

Work undertaken by the department includes all classes of sheet metal and stainless steel fabrication for kitchens, also for ships' galleys, pantries, and stores. With the improved facilities now available, fabrication from mild steel plate up to 1¼ in. thick will also be carried out on an increasing scale. A general view in the new building is shown in the accompanying illustration.

A General View in the New Press and Fabricating Building at the Works of Carron Co.

Newman "Thoroughbred" Single-phase Motor

The drip-proof enclosed, capacitor start, electric motor, here shown, has recently been added to the range made by Newman Industries, Ltd., Yate, Bristol, and has been specially designed for operation on single-phase supplies.

A noteworthy feature of the design is that two fairly small condensers are fitted, which are held in cored openings in the feet of the cast iron frame, by spring clips. Since the condensers are totally enclosed the risk of damage is obviated, and with this arrangement the space occupied by the motor is considerably reduced.

Known as the Thoroughbred, the motor is particularly intended for use in the agricultural and dairy industries, and is at present available as a 4-pole machine, with ratings of 1, 1½, 2 and 3 h.p., for continuous operation on supplies up to 480 volts. The range will later be extended to cover 4- and 6-speed pole-changing machines in sizes from ½ to 5 h.p. A fairly high starting torque, with low current consumption, is provided, and the motor has class A insulation which permits a temperature rise of 40 deg. C. It is built in accordance with the American NEMA specification for frame size.

A centrifugal switch with a dust-tight cover is housed in a square recess at the centre of the fan, and a thermal overload protection unit, arranged for hand or automatic operation, can be fitted. The end covers can be turned through 180 deg. so that the ventilation openings can be set downwards when the motor is mounted in the inverted position. A hole for conduit entry can be provided at either side of the end cover at the non-drive end of the frame, and a plate attached to this cover can be readily swung clear to give access to the stud-type terminals.

Newman "Thoroughbred" Single-phase Motor

Books Received

THE COAL INDUSTRY OF THE U.S.S.R., Part 2. Appendix 4, Roof Supports. The National Coal Board, Hobart House, Grosvenor Place, London, S.W.1. 60 pp. [Price 5s. Post free 5s. 6d.]

Appendix 4 to the Report by the Board's Technical Mission to Russia, which was published last year, has now been issued. It is concerned with roof supports, and includes sections on steel props and bars, chocks, composite supports, mechanized supports, and steep seam supports.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY—50TH ANNUAL REPORT. Imperial College, South Kensington, London, S.W.7.

Covering the jubilee year of the College (1956-57) this Report, which extends to 91 pages, includes sections, for example, on academic developments, new buildings and building plans, staff changes, honours and distinctions, and general finance. The number of full time students during the period covered was 2,215, an increase on the previous year of 142.

MATERIALS HANDLING. Bristol and Bath Productivity Association, 34 Whiteladies Road, Bristol, 8. 50 pp. [Price 3s.]

A Working Party of managers and trade unionists, set up by the Bristol and Bath Productivity Association, has been examining, for the past two years, materials handling methods employed by firms in the area. Their conclusions, and numerous examples of the best current practice are included in this report. Sections are devoted to "the approach to material handling"; manual handling; palletization; loading lorries; conveyors; lifting appliances; pumping and suction; and the "revolving fund" for industry. There is also an appendix on palletization and fork lift truck operations.

ENGINEERING MECHANICS. (Second Edition.) By A. Higdon and W. B. Stiles. Longmans, Green & Co., Ltd., 6 and 7 Clifford Street, London, W.1. 585 pp. [Price 32s. 6d. net.]

Mechanics, an indefinite mixture of statics, kinetics and dynamics, is essential to the pursuit of all successful design engineering. Although many treatises have been written on the subject, the present volume will be welcomed for its masterly blend of theory with solution of practical problems. The topics selected for discussion are those particularly useful to the engineer.

Aspects of mechanics which are covered include the resolution of forces, centroids, equilibrium and friction, absolute and relative motion, force and acceleration, work, energy, impulse, momentum and mechanical vibration. Numerous examples are fully worked out in the text, and the many diagrams are clear and apt.

News of the Industry

Manchester and District

FORWARD BUYING OF PIG-IRON RESTRICTED.—There is still little forward buying of Midland No. 3 pig-iron by Lancashire foundries. Supplies at the furnaces are more than adequate, and users are content to confine fresh commitments to prompt and near deliveries. Patchy conditions among textile machinery builders and makers of light castings, also at the jobbing foundries, continue to be reflected in the tonnages of common irons which are going into consumption, although the aggregate quantity being taken up by the foundries as a whole is slightly larger than it was a short time ago. For delivery in the Lancashire zone, Derbyshire No. 3 pig-iron is quoted at £21 1s. 3d. per ton. There is a fair call for West Coast haematite pig-iron, at £25 5s. per ton, delivered in the Manchester area.

FEWER ENQUIRIES FOR LIGHTER STEEL PRODUCTS.—Fresh enquiries for certain classes of steel materials, mainly the lighter products, are less in evidence, and the tendency among users to work down stocks, rather than to enter into fresh commitments for the time being, continues. Heavy electrical engineers and other users of steel plates, however, are calling for deliveries against existing contracts, and a steady demand is reported for the larger sizes of round bars. In structural materials, trading is again rather quieter, and this applies especially to the lighter descriptions. For special alloy steels, in rounds and hexagons, there is still a fair flow of specifications. Forgemasters and wire-drawers are absorbing steady supplies of semi-finished steels.

GEORGE RICHARDS & CO., LTD., Broadheath, are busy with the production of their standard ranges of horizontal boring machines and vertical boring and turning mills, several of which are destined for Commonwealth and Continental countries. The former include both traversing- and non-traversing spindle types, in sizes from No. 1 to No. 6, some of which have wider beds and larger table capacities than normal, while the latter range from 4 to 16 ft. diameter capacity. In addition, we may note vertical spindle, horizontal keyseating machines of various types in progress, and in the heavy planing machine section our attention was drawn to a 30- by 16- by 13-ft. machine, to which we hope to refer again in due course.

TILGHMAN'S LTD., Broadheath, have a good order book for their various types of equipment for cleaning castings and forgings, including rotary table and conveyor-type airless wheelabrators of various sizes, Tumblasts and shot-blast plants. A recent development is the introduction of a machine for cleaning ships' plates, to meet the oil companies' requirement that plates used in tanker construction should be shot-blasted and painted. We hope to make further reference to this machine in due course. Orders are also in hand for air compressors of various capacities, including the Uniblok, Twinblok and Comoblok machines. A recently-built mechanical shot blast room plant, which is claimed to be the largest of its type in the world, measures 30 by 25 by 16 ft., and has been installed at the works of F. H. Lloyd & Co. Ltd., Wednesbury. It is equipped with a bogie capable of carrying 100 tons, to which an oscillating motion is imparted during the blast cleaning cycle, and, in addition, the table has a rotary motion. We hope to describe this plant more fully at a later date.

LUKE & SPENCER, LTD., Broadheath, continue to do a good business in their standard ranges of single- and double-ended snagging and tool grinding machines, equipped with abrasive wheels from 12 to 30 in. diameter. On export account we may note machines destined for the South African Railways. Portable swing-frame grinders, equipped with wheels of 16 and 20 in. diameter, are another active line. The grinding wheel section is experiencing a brisk call for all types of wheels and segments.

CLARE-COLLETS, LTD., Broadheath, report a lively demand for all sizes of their patent milling chucks and equipment, as well as for standard and special milling cutters, end mills, and routing cutters. Since our last visit, a Jones-Shipman tool and cutter grinding machine and a John Lund Precimax plain cylindrical grinding machine have been installed.

THE CHURCHILL MACHINE TOOL CO., LTD., Broadheath, inform us that there is a good call for their various types and sizes of precision grinding machines on both home and export account. Orders in hand cover plain cylindrical grinding machines up to 36 in. swing; universal internal and centreless types; horizontal- and vertical-spindle, also piston ring type surface grinders;

openside slideway grinders, and broach and spline grinders. We hope shortly to describe a 36-in. swing heavy-duty plain cylindrical grinder, to admit lengths up to 30 ft., which has recently been supplied to William Asquith, Ltd., Halifax, for grinding machine tool shafts and feed screws. A new design of 18- by 6-in., horizontal spindle, surface grinder has just been introduced, to which we hope to make further reference. Among the larger machines in progress we may note heavy-duty roll grinders of both the traversing table and traversing wheel types, and railway shop machines for grinding the journals of carriage, wagon and locomotive axles, also locomotive crankpin grinding and quartering machines.

H. W. KEARNS & Co., LTD., Broadheath, are fully employed on home and export orders for horizontal boring machines ranging in sizes from No. 0 to No. 5, and including S-type machines. In the works we noted machines with extended tables and wider beds than normal, plano-table machines, and machines fitted with Optimetric equipment. Our attention was drawn to the No. 0 plano-table type machine fitted with the British Thomson-Houston electronic co-ordinate setting system, which was on view at the last Machine Tool Exhibition, at Olympia, and is now in operation at these works. An order for another of these machines is in hand. Export destinations for the firm's products include Australia, Canada, India and Holland. Extensions to one of the erection bays at these works are in progress.

CHARLES S. MADAN & Co., LTD., Broadheath, report a well-maintained demand for small, medium and large-capacity Airhydropumps, for the hydraulic testing of valves, castings and pressure vessels. A new medium-size pump has recently been introduced, to which we hope to make further reference in due course. There is a steady demand for Vortex revolving centres, also for non-ferrous metal castings.

TAYLOR TOOLS & SUPPLIES, LTD., Broadheath, are occupied on a variety of belt grinding and polishing machines of both standard and special designs. Our attention was drawn to recent developments which comprise a small internal belt grinding machine for operating in restricted spaces, and a small vertical backstand machine for grinding and polishing small components. Fuller descriptions of these machines will be published shortly.

ESSEX TOOL & GAUGE Co., LTD., Altrincham, are fully engaged with the production of various types of milling, grinding, boring and inspection fixtures, and drill jigs. Other products include sine bars, sine plates, and sine bar centres of 15-, 20- and 25-in. capacities, single- and double-ended plug gauges, plate gauges, alignment bars, ball-end test bars, adjustable bench centres, and square-testing fixtures. The latest addition to plant is a Newall No. 0 jig boring machine. A selection of the firm's products will be on view at the Gauge and Tool Exhibition to be held at Olympia, London, from May 12 to 21.

H. B.

Obituary

MR. H. T. EATWELL, A.M.I.E.E., managing director and joint deputy chairman of G. A. Harvey & Co. (London), Ltd., Greenwich Metal Works, London, S.E.7, died on February 20. He was educated at Wilson College and Northampton Engineering College, London, and after gaining practical experience for some years he joined the company in 1929 as a sales engineer in the heavy construction department, of which he was subsequently appointed manager. Later, Mr. Eatwell became personal assistant to the senior director and works manager. In this capacity, he was responsible for planning and carrying out the re-organization of many production departments. He was appointed a director in 1937, managing director in 1947, and, since 1952, had also held the post of deputy chairman.

Correction

In the article on Methods and Equipment for Checking External Tapers (MACHINERY, 92/483—28/2/58), the address of Engineering & Scientific Equipment, Ltd., the agents in this country for La Précision Mécanique, should have been given as 33 Minster Road, London, N.W.2.

Industrial Notes

NICOR (WILLENHALL), LTD.—The address of this company is now Park Road, Willenhall.

WESTOOL, LTD., St. Helen's Auckland, Co. Durham.—The telephone numbers of this company have been changed to West Auckland 551/5.

FREDERICK W. EVANS, Ltd., Plastic Works, Long Acre, Birmingham, 7, inform us that they are now in occupation of a new and larger toolroom which is fully equipped with modern machines.

ENGLISH ELECTRIC CO., LTD., Stafford, have received a contract, valued at £1,160,000, from the Hydro-Electric Power Commission of Ontario, Canada, for a 100-megawatt steam turbo-alternator set for the new power station at Thunder Bay, Fort William.

BLACK & DECKER (NEDERLAND) N.V., is the title of a subsidiary company in Holland which has been established by Black & Decker, Ltd., to provide a complete repair and maintenance service for their electric tools. The address of this company is 109 Vondelweg, Rotterdam.

RANK CINTEL, LTD., is the new title which has been adopted by the company formerly known as Cinema-Television, Ltd. The address (Worsley Bridge Road, Lower Sydenham, London, S.E.26) has not been changed, and there will be no alteration in the trading activities of the company.

METROPOLITAN-VICKERS ELECTRICAL CO., LTD., Trafford Park, Manchester, 17, have received an order, valued at £2½ million, for two 120,000 kW. steam turbine alternators for installation in a power station in Poland. It is stated that this is the largest single order placed in this country by Poland since the war.

W. E. SYKES, LTD., Manor Works, Staines, Middlesex, inform us that they will participate in the exhibition of the American Society of Tool Engineers to be held in Philadelphia in May. Their exhibits will include a Sykomatic magazine loading gear generator and a Sykes type 3C gear generator of 40-in. capacity.

ASSOCIATED BRITISH MACHINE TOOL MAKERS, LTD., have opened a new office at Royal London Buildings, Baldwin Street, Bristol, 1 (telephone number, Bristol 27918), under the management of Mr. William Long. The territory which will be covered from this office comprises Bristol, South Wales, and South West England (including Devon and Cornwall).

CASELCO, LTD., 46 Park Square, Leeds (telephone numbers Leeds 3-0285/6 and 3-1146), have been appointed by Twiflex Couplings, Ltd., a subsidiary of Sheepbridge Engineering, Ltd., sole selling agents for Yorkshire for Twiflex products including automatic clutch couplings, flexible couplings up to very large capacities, holdback brakes, and over-run couplings.

CONFERENCE ON FINANCIAL INCENTIVES.—The Industrial Welfare Society (Inc.), Robert Hyde House, 48 Bryanston Square, London, W.1, are to hold a one-day conference at the above address on March 25. Reasons for adoption and discontinuation of incentive schemes in industry will be discussed, and an attempt will be made to show where incentives can best be applied and under what conditions.

THE NATIONAL GAS & OIL ENGINE CO., LTD., Wellington Road, Ashton-under-Lyne, Lancs., recently delivered their first production free piston gasifier. Known as the GS.34, the free piston gasifier is basically a supercharged diesel engine without a crankshaft. Its function is not to supply mechanical power but to act as a generator for power gas which is then used to drive a gas turbine coupled to the driven machine.

BRITISH STEEL FOUNDERS ASSOCIATION, Broomgrove Lodge, Broomgrove Road, Sheffield, 10. B.S.F.A. Bulletin Vol. 2, No. 7, is concerned with methods study in the steel foundry. It includes sections under the headings: the functions of a methods study department; the selection of production and inspection methods; methods instruction forms; and the advantages of operating a methods study department. The two sides of a typical foundry methods card are reproduced.

NEWMAN INDUSTRIES, LTD., Yate, Bristol, inform us that their agencies now include the following: Polak (Czechoslovakian) die casting machines; Pfeifer (German) horizontal boring machines and lathes; Linsinger T. techn. E. (Austrian) thread whirling and cutting attachments; T.O.S. (Czechoslovakian) vertical spindle surface grinders, and centreless grinders; Technompex (Hungarian) centre lathes, radial drills, milling machines, and spark erosion machines; and Wiener Werkzeug (Austrian) jig borers.

THE INSTITUTE OF WELDING, 54 Princes Gate, Exhibition Road, London, S.W.7, have arranged for a series of annual lectures, which will be given by eminent scientists and engineers and will be devoted to subjects of wide general interest. The first of these lectures will be delivered by Prof. Sir Alfred Pugsley, O.B.E., D.Sc., F.R.S., in the Conference Hall of the Institute at 6.00 p.m. on March 12. The subject will be "The Influence of Welding on Structural Design," and all those interested are invited to attend.

W. D. HORNE & CO., LTD., Woodbridge House, Aylesbury Street, London, E.C.1, have issued a folder outlining their activities which include a stores and spares service for production and maintenance engineers. With this service, parts made under contract can be held in stock against future requirements. The company undertake the machining of nylon and other non-metallic materials, also ferrous and non-ferrous metals. In addition, they manufacture and assemble light engineering units. Plant available includes capstan and centre lathes, vertical and horizontal millers, drilling machines, and cylindrical grinders.

A CONFERENCE ON ELECTRONIC DIGITAL COMPUTERS and their industrial applications will be held by the Birmingham College of Technology at Gosta Green on March 26. The first of a series of one-day conferences, it will be concerned particularly with Ferranti computers, and the subjects of the speakers will be as follows: a survey of the components of a computer and their functions; the philosophy of Ferranti computing systems for com-

mercial, industrial and scientific work; commercial and industrial applications with special reference to stock recording, material control and production planning; mathematical and scientific work on computers, in the fields of research, engineering, and design. The conference fee is £2, and further details can be obtained from the Registrar, College of Technology, Suffolk Street, Birmingham, 1.

Coming Events

INSTITUTION OF PRODUCTION ENGINEERS. *Ipswich and Colchester Section.* March 14, at 7.30 p.m., at the Britannia Works Canteen, Davey Paxman & Co., Ltd., Colchester; lecture on "Work Study," by Rear Admiral R. S. Warne. *Stoke-on-Trent Section.* March 17, at 7.30 p.m., at the Grand Hotel, Hanley, Stoke-on-Trent; lecture on "Powder Metallurgy," by P. R. Marshall, B.Sc., Ph.D. *Swansea Section.* March 14, at 7.30 p.m., at the Central Library, Alexandra Road, Swansea; lecture on "Training for Industry," by R. B. Southall.

INSTITUTION OF ELECTRICAL ENGINEERS. *Mersey and North Wales Centre.* March 17, at 6.30 p.m., at the Town Hall, Chester; paper on "Recent Uses of Ultrasonics in Investigating the Characteristics of Materials," by J. Lamb, Ph.D., M.Sc.

INSTITUTION OF ENGINEERING INSPECTION. *London Branch* March 12, at 6.45 p.m., at the Royal Society of Arts, John Adam Street, Adelphi, W.C.2; paper on "Practical Engineering Metrology—a Review of the Standards Room," by G. H. Sharp. *Leeds Branch.* March 11, at 7.30 p.m., at the Leeds Church Institute, Albion Place, Leeds, 1; paper on "Investment Casting by the Lost Wax Process," by W. N. Jones.

Personal

MR. L. L. G. VAUGHAN has been appointed sales office manager for Hardinge Machine Tools, Ltd., Hampton Road West, Hanworth, Feltham, Middlesex.

MR. A. V. SOWMAN, M.I.E.E., has been appointed the first managing director of Crompton Parkinson (Chelmsford), Ltd., a recently formed subsidiary of Crompton Parkinson, Ltd. He was previously a director and general manager.

MR. PETER M. GAVIN has joined the staff of Paul Granby & Co. Ltd.. 39 Victoria Street, Westminster, London, S.W.1, as sales representative in the North Midlands (Yorkshire, Lancashire, Cheshire, Derbyshire, Lincolnshire, and North Staffordshire). MR. JOHN DODD, who was formerly sales representative in the Midlands and North Midlands, is no longer employed by the company. No new appointment will be made for the Birmingham and Coventry areas, for which Mr. Paul Granby will be personally responsible, assisted by Mr. D. Charles-Edwards.

SIR JAMES SWINBURNE, F.R.S., recently celebrated his hundredth birthday. Until 1948 he was chairman of Bakelite, Ltd., 12-18 Grosvenor Gardens, London, S.W.1, and is now honorary president of the company. A distinguished engineer, he was one of the world's pioneers in the field of synthetic resins, and his original work on phenolics at the beginning of the century was a major contribution to the development of the modern plastics industry. During his long life Sir James has had many interests. In addition to being a Fellow of the Royal Society, he is a past president of the Institution of Electrical Engineers and of the Faraday Society, and a member of the Institution of Civil Engineers. His hobbies include horology, and he has published books and papers on the subject.

Scrap Metals

†LONDON.—‡Prices per ton for non-ferrous scrap metals free from iron are as follows:—clean copper wire, untinned and free from lead and solder, £130; clean heavy copper, untinned and free from lead and solder, £123; second grade copper wire, £117; clean light copper £114; braziery copper, £106; gunmetal, £112; brass mixed, £74; lead, net, £58; zinc, £25; cast aluminium, £91; old rolled aluminium, £124; battery lead, £31; unsweated brass radiators, £61; hollow pewter, £495; black pewter, £365.

MIDLANDS..—There has been no appreciable change in the general trading position as regards the disposal of ferrous scrap to steelworks and blast furnaces. The majority of consumers are only accepting deliveries on an allocation basis, and the quantities vary from week to week. Scrap from the Midlands is being forwarded to works all over the country, but markets in South Wales are particularly quiet.

The greatest difficulty is being experienced in connection with bushy turnings, light iron, No. 5 bundles and hydraulically compressed destructor scrap. Prices offered by merchants for these grades have fallen considerably, as collection and stocking of light scrap, in particular, can be very expensive. Cast-iron borings and chipped steel turnings are forthcoming regularly in the Midlands, and requests for increased allocations are being made continually by merchants, to ensure that there are no hold ups in clearance from factories.

Foundry scrap available is in excess of market requirements but there is a fair business in short steel and cast iron. The demand for clean cast iron cylinder blocks is very keen and all such material offered is quickly taken in the Black Country area. With many scrap yards holding excessive stocks, there is considerably less interest in parcels of oversize scrap. Low nickel content scrap does not command attention at special prices.

Current maximum control prices, delivered consumers' works, are now: *Heavy steel No. 1, 217s. 6d.; *heavy steel No. 2, 196s.; *heavy steel No. 4, 207s. 6d.; *heavy steel No. 5, 195s. 6d.; light iron No. 8, 149s.; short turnings No. 9 (free from alloy), 167s. 3d.; light steel No. 11, 164s. 3d.; bushy turnings, 117s.; short alloy turnings, 160s. 9d.; short steel No. 2, 233s. 3d.; machinery cast, 233s.

Prices may be increased up to 2s. 6d. per ton according to quantities tendered over a given period.

* For use by Round Oak Steelworks, Brierley Hill, increase by 1s. 6d. per ton.
† George Cohen, Sons & Co., Ltd., Commercial Road, E.14.
‡ Subject to market fluctuations.

Machine Tool Share Market

Stock markets, generally, were very quiet during the past week, but after a period of dullness and uncertainty, an improving tendency developed, which was maintained until the close.

Initial easiness in the gilt-edged section was followed by steady to firm conditions, and, on balance, gains were shown among British Funds and other high grade fixed interest stocks.

Industrial share markets were unsettled and displayed an easier trend for the most part. Nearly all sections were depressed, but near the finish the general tone steadily strengthened under the influence of a number of good company dividend announcements, and closing prices were above the lowest.

Among machine tool issues, Churchill Machine advanced 1½d. to 17s. 6d.; Coventry Machine Tool, 3d. to 8s. 9d.; Craven Bros. (Manchester), 3d. to 6s.; and Alfred Herbert, 3s. 9d. to 62s. 6d. On the other hand, Edgar Allen lost 1s. 3d. at 26s. 9d.; Arnott & Harrison, 3d. at 14s.; Kitchen & Wade, 3d. at 10s. 3d.; Chas. Churchill, 1½d. at 4s. 6d.; Clarkson (Engineers), 6d. at 10s.; Coventry Gauge & Tool, 6d. at 14s.; John Holroyd "A," 6d. at 10s. 6d.; Modern Engineering, 1s. at 10s.; Ambrose Shardlow, 1s. at 33d. 6d.; and John Shaw & Sons (Wolverhampton), 4½d. at 11s. 7½d.

ALFRED HERBERT, LTD.—Final dividend 8 per cent (tax free), making, with the interim already paid, a total distribution of 12 per cent (tax free) for the year ended October 31 last, an increase of 4½ per cent on the total distribution for the preceding year.

Trade Publications

ASHMORE, BENSON, PEASE & CO., Stockton-on-Tees.—Fully-illustrated brochure showing various representative Meehanite castings in a wide range of sizes. A summary of the physical properties of Meehanite metal is included.

DEB CHEMICAL PROPRIETARIES, LTD., Belper, Derbyshire. Leaflet describing the Swarfega waterless washing station for which various advantages are claimed. The station comprises a dispenser for waterless skin cleanser, two paper towel dispensers, and a receptacle with a canvas sack for soiled towels.

RUSSELL AUTO-FEED SCREWDRIVERS (BRANCH OF NEEDLE INDUSTRIES, LTD.), Studley, Redditch.—Folder describing the Russell screw or pin driving machines with magazine feed which can be supplied for hand operation, or single or continuous cycle pneumatic operation. In addition to bench machines, the range includes fixed and hinged types for wall mounting.

COMPANY		Denom.	Middle Price
Abwood Machine Tools, Ltd.	Ord.	1/–	9d.
Armstrong, Stevens & Son, Ltd.	Ord.	5/–	7/9
Allen (Edgar) & Co., Ltd.	Ord.	£1	26/9
,, ,,	5% Prf.	£1	14/6*
Arnott & Harrison, Ltd.	Ord.	4/–	14/–
Asquith Machine Tool Corp., Ltd.	Ord.	5/–	18/9xd
,, ,, ,,	6% Cum. Prf.	£1	17/9
Birmingham Small Arms Co., Ltd.	Ord.	£1	25/–
,, ,, ,,	5% Cum. "A" Prf.	£1	15/–
,, ,, ,,	6% Cum. "B" Prf.	£1	17/6
,, ,, ,,	4% 1st. Mort. Deb.	Stk.	85/–
British Oxygen Co., Ltd.	Ord.	£1	29/–xd
,, ,, ,,	6½% Cum. Prf.	£1	21/6
Brooke Tool Manufacturing Co., Ltd.	Ord.	5/–	5/6
Broom & Wade, Ltd.	Ord.	5/–	9/9
,, ,,	6% Cum. Prf.	£1	17/9
Brown (David) Corporation, Ltd.	5½% Cum. Prf.	£1	14/4½
Buck & Hickman, Ltd.	6% Cum. Prf.	£1	17/6
Butler Machine Tool Co., Ltd.	Ord.	5/–	6/3
,, ,, ,,	5% Cum. Prf.	£1	13/9
C.V.A. Jigs, Moulds & Tools, Ltd.	5½% Red. Cum. Prf.	£1	13/9
Churchill (Charles) & Co., Ltd.	Ord.	2/–	4/6
,, ,, ,,	6% Cum. Prf.	£1	26/3†
Churchill Machine Tool Co., Ltd.	Ord.	5/–	17/6
,, ,, ,,	6% Cum. Prf.	£1	18/9
Clarkson (Engrs.), Ltd.	Ord.	5/–	10/–
Cohen (George), Son & Co., Ltd.	Ord.	5/–	10/9
,, ,, ,,	4½% Cum. Prf.	£1	14/3
Coventry Gauge & Tool Co., Ltd.	Ord.	10/–	14/–
,, ,, ,,	5% Cum. Red. Prf.	£1	16/3
Coventry Machine Tool Works, Ltd.	Ord.	4/–	8/9
Craven Bros. (Manchester), Ltd.	Ord.	5/–	6/–
Elliott (B.) & Co., Ltd.	Ord.	1/–	3/–
,, ,,	4½% Red. Cum. Prf.	£1	13/9
Export Tool & Case Hardening Co., Ltd.	Ord.	2/–	1/6
Firth Brown Tools, Ltd	4% Cum. Prf.	£1	12/–
Greenwood & Batley, Ltd.	Ord.	£1	46/10½

COMPANY		Denom.	Middle Price
Harper (John) & Co., Ltd.	Ord.	5/–	14/–
,, ,,	4½% Red. Cum. Prf.	£1	12/9
Herbert (Alfred), Ltd.	Ord.	£1	62/6
Holroyd (John) & Co., Ltd.	"A" Ord.	5/–	10/6
,, ,,	"B" Ord.	5/–	9/9
Jones (A. A.) & Shipman, Ltd.	Ord.	5/–	21/3
,, ,, ,,	7% Cum. Prf.	5/–	5/–
Kayser, Ellison & Co., Ltd.	Ord.	£1	53/–
,, ,, ,,	6% Cum. Prf.	£1	18/3
Kendall & Gent, Ltd.	Ord.	5/–	7/9
Kerry's (Gt. Britain), Ltd.	Ord.	5/–	5/6
Kitchen & Wade, Ltd.	Ord.	4/–	10/3
Martin Bros. (Machinery), Ltd.	Ord.	2/–	2/4½
Massey, B. & S., Ltd.	Ord.	5/–	7/3
Modern Engineering Machine Tools, Ltd.	Ord.	5/–	10/–
Newall Engineering Co., Ltd.	Ord.	2/–	5/–
Newman Industries, Ltd.	Ord.	2/–	2/9
,, ,,	6% Prf. Ord.	5/–	5/6
Noble & Lund, Ltd.	Ord.	2/–	4/9xd
Osborn (Samuel) & Co., Ltd.	Ord.	5/–	16/3
,, ,, ,,	5½% Cum. Prf.	£1	25/–
Pratt (F.) & Co., Ltd.	Ord.	5/–	20/–
Scottish Machine Tool Corporation, Ltd.	Ord.	4/–	5/3
Shardlow (Ambrose) & Co., Ltd.	Ord.	£1	33/6
Shaw (John) & Sons, Wolverhampton, Ltd.	Ord.	5/–	11/7½
Sheffield Twist Drill & Steel Co., Ltd.	Ord.	4/–	35/–
,, ,, ,, ,,	5% Cum. Prf.	£1	15/–
Stedall & Co., Ltd.	Ord.	5/–	4/9
Tap & Die Corporation, Ltd.	Ord.	5/–	7/9
,, ,, ,,	4½% Deb. 1961-1977	Stk.	82/–
Wadkin, Ltd.	Ord.	10/–	19/6
Ward (Thos. W.), Ltd.	Ord.	£1	72/–
,, ,,	5% Cum. 1st. Prf.	£1	15/6
,, ,,	5% Cum. 2nd Prf.	£1	24/3
Willson Lathes, Ltd	Ord.	1/-	2/4½

The Middle Prices given in the list are in several cases nominal prices only and not actual dealing prices. Every effort is made to ensure accuracy, but no liability can be accepted for any error. * Sheffield price. † Birmingham price.